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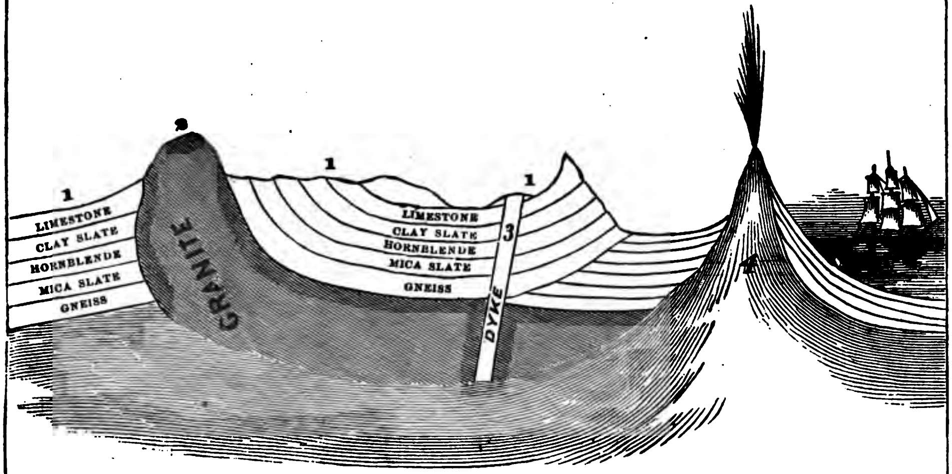

POSITION OF ROCKS.

1. Stratified. 2. Unstratified. 3. Dykes. 4. Volcanic.

HALL'S

ALPHABET OF GEOLOGY:

OR,

FIRST LESSONS

IN

GEOLOGY AND MINERALOGY.

WITH SUGGESTIONS ON

THE RELATION OF ROCKS TO SOIL.

BY

S. R. HALL, LL.D.,

AUTHOR OF "LECTURES ON SCHOOLKEEPING," "GEOGRAPHY AND HISTORY OF VERMONT," ETC.

WITH ILLUSTRATIONS.

REVISED EDITION.

NEW YORK:
SHELDON & COMPANY, 677 BROADWAY
AND 214 & 216 MERCER STREET,
UNDER GRAND CENTRAL HOTEL.
1874.

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PREFACE.

THIS work has been written at the solicitation of many earnest friends of popular education, and is commended to both parents and instructors. It is not designed to give a thoroughly scientific arrangement or description of Geology, Mineralogy, etc., but such an amount of information as may be acquired by the young while prosecuting other studies, and by those of any age who have not time or opportunity for more extended research.

The belief of the writer is that it may be introduced, with great propriety, into district or common schools; and would be eminently useful in furnishing the youthful mind with the key necessary to open many avenues which, from the want of a suitable text-book, have hitherto been closed. The young are always interested in minerals, if they can learn their names and uses. No subject is better adapted to fix attention and lead to early habits of comparison and classification, so essential to be early cultivated. It is believed that every intelligent instructor will need only one experiment to become fully convinced that the study of any department of NATURAL SCIENCE is eminently interesting to the young. No one branch will excite greater interest, or is more worthy of the attention of parents and teachers, than that presented in this volume.

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INTRODUCTION.

TO THE YOUNG.

LONG-CONTINUED observation has convinced the writer of this little work that much time is spent by the young in efforts to learn some things from which but very little benefit is derived, and at the same time other things are neglected which would be highly useful. Among the latter is some knowledge of the ROCKS, MINERALS, METALS, and SOILS, which are objects daily seen, but of the names, importance, and value of which many remain ignorant even to old age.

There has been great progress in many things: schools and books have been greatly improved since the author commenced his efforts as an instructor many years ago. But children and youth, in families and schools, generally, are just as ignorant now of common rocks, minerals, soils, etc., as they were fifty years ago. One reason, doubtless, is, that while text-books have been prepared to teach the rudiments, not only of grammar, arithmetic, and geography, but of botany, zoölogy, astronomy, and many other branches, *no text-book* has been prepared on the subjects of geology and mineralogy, which has been equally adapted to the young.

Names of minerals, stones, and rocks, as well as metals, are found in almost every book or newspaper. If one resort to a dictionary to learn the meaning, the words employed to define are just as unintelligible sometimes as the word to be defined.

In this little book I have endeavored to supply this deficiency, and have made it so plain and easy to be understood that any child of common capacity, ten or twelve years of age, can comprehend it, and study it with advantage. It is called the ALPHABET OF GEOLOGY, because nine simple minerals compose, either separately or combined, a very large part of all the rocks and soils of the earth.

The "Family and School Cabinet," of one hundred specimens, described in the Appendix, embraces not only the nine simple minerals, with their most essential varieties, but specimens of the most important rocks which they aid to form; also several beautiful crystalline minerals, together with the more common and most useful metals and ores; also several combustible substances of very great importance to man.

It is very desirable, that a small cabinet be placed in every school-house and family, as it may be, at an expense very trifling compared to its use and value. But if not procured by parents or instructors, the deficiency may, in a measure, be supplied by every earnest and intelligent youth in the course of a few years.

As soon as any specimen is obtained, let it be numbered according to the catalogue, and then let it be studied till it is so familiar as to be known wherever seen. From one-tenth to one-fourth of the specimens numbered in the catalogue can be obtained in some single towns. Every child even can begin to collect a little cabinet of his own as soon as he begins to study the "Alphabet of Geology."

Quartz or silex, the first letter, can be found in nearly every place; and usually several varieties of it. Feldspar, mica, clay, and limestone can be procured also in a very large number of towns; for, if not found in ledges and large rocks, these may, in many instances, be procured from the rolled stone in the walls, gravel, and clay banks, etc. Specimens of limestone or marble may be seen in every cemetery, and can be readily procured at any shop where marble is manufactured.

No young person should pass by or see a mineral or stone without the inquiries, What is the name of it? Is it of any importance? Of what is it composed? One of the wisest men of whom we have knowledge, President Dwight, being asked how he had obtained so much knowledge on a great variety of subjects, replied, "I gained it by not being ashamed to *ask questions*, and to receive information from any one able to teach me. Every person I meet with, doubtless knows something, on some subject, that I do not, and I always contrive to make him my teacher in that particular."

If every youth will adopt this course in early life, and continue it, the next generation will become vastly wiser than the present. Will you not all form this habit? Your parent, teacher, physician, minister, or some one, will be able either to answer your inquiries, or direct you to some person, or to some book, where you may obtain answers. After having gained a knowledge of what is contained in this book, you will be prepared to peruse a more extended and more systematic treatise. Loomis' "Elements of Geology," "Hitchcock's Geology of the World," and many other books recently published, will prove eminently useful, after having studied these introductory lessons.

PART FIRST.

ALPHABET OF GEOLOGY.

LESSON I.

ROCKS—HOW FORMED AND CLASSIFIED.

WHENEVER we walk or ride abroad, among the more common objects we behold are rocks, stones, and soils. The science which teaches how the rocks and minerals were formed, and of what they are composed, is called Geology. A branch of this science is called Mineralogy. Rocks, minerals, and metals constitute, chiefly, the solid part or *crust* of the earth. The soil which is cultivated in the fields, and which supports vegetation, is mostly decomposed rock. Do you inquire, How were the rocks formed, and of what are they composed? I will tell you.

Rocks may be divided into three great classes.

1. Those which were formed by a deposition of particles from water.[1] These are called *sedimentary* or *stratified rocks;* some of them are fossiliferous.

---

[1] When land borders on a lake, sea, or ocean, brooks and rivers will be formed, carrying the water from the land into the lake, sea, etc. The action of running water wears off particles of the rock, and bears

This class is now constantly forming at the bottom of ponds, lakes, seas, and oceans. You can see a specimen in every clay-bed or sand-bank which you may examine. These were all formed at the bottom of lakes, seas, etc.

2. Those formed by the agency of heat, called *igneous rocks.*[1] These rocks were once in a state of fusion, or were melted, like the lava which flows out from a volcano. When slowly cooled, without coming to the air, the rocks of this class are very compact and hard, and have a *crystalline* structure. They are often called crystalline rocks. When cooled on the surface of the earth, they are called lavas, or pumice stones, and are very light or porous.

3. Rocks formed by both these agencies united. Thus clay, after being deposited from water, if subjected to a degree of heat not sufficient to fuse or melt it, becomes a hard, slaty rock. This class of rocks is more common, perhaps, than any other.

---

them onward till they are deposited at the bottom of the still water. After great rains, and when these streams are swollen, mud, clay, sand, and rolled stones are borne onward, and form beds or deposits, burying with them plants, flood-wood and dead animals. These materials aid to form new rocks, which become hard by heat, or other causes. This process has been carried on during vast ages past, so that a large part of the rocks now found near the surface of the earth are of this class.

[1] Some geologists prefer a different classification,—*plutonic*, *volcanic*, *non-fossiliferous stratified* rocks, and *fossiliferous stratified rocks.*

The igneous rocks were sometimes forced up through the stratified rocks. These are called trap rocks, or dikes. The position of all stratified rocks would have been very uniform if there had never been any volcanoes and earthquakes. Mountains have been elevated or raised up, in some instances, to the height of several miles. Most, if not all, the present dry land has been raised up from beneath the surface of the ocean. The ocean, it is probable, now covers much that was once dry land, but has settled down or sunk.

Much of the present dry land was for a long time covered by the waters of the ocean. This is proved by the structure of the rocks, and the sea-shells, fish, and other animals and vegetables, called *organic remains*, found imbedded in the strata. Such rocks are called *fossiliferous.*

Now, look at the diagram, and see how the rocks are situated. Granite, though naturally the lowest rock, has, in many places, been forced up through the stratified rocks, and is found at a higher level, as at (2) in the diagram. The stratified rocks have been separated by it, contorted, or bent, so that, instead of being horizontal, they are inclined, and often vertical. Volcanoes have produced a similar effect on the stratified rocks through which lava has been forced up, as seen at (4). Dikes, being usually narrow, have not produced so much disturbance (3).

NOTE.—Though all principal rocks are divided into the three great divisions specified, yet these classes are necessarily subdivided. Stratified rocks are divided into two classes, fossiliferous and unfossiliferous. A fossiliferous rock is one in which vegetable or animal remains are found. If organic remains were ever embraced in the unfossiliferous stratified rocks, all appearance of them has been lost by the changes those rocks have undergone since they were formed. Many of them have been subjected to great heat. The fossiliferous rocks are described under the following divisions: Upper Silurian, Lower Silurian, Devonian, and Permian.

QUESTIONS ON LESSON I.

What common things do you see, when you walk or ride abroad? What is the science called which treats of rocks and stones? What is a branch of it called? How many great classes or kinds of rocks? What is the first? What are rocks of this class called? Are rocks of this kind now forming? Where? Where may you see specimens of this class? How is the second class of rocks formed? What are the rocks of this class called? What is the state of the igneous rocks that were slowly cooled? What is their structure? What is said of volcanic rocks when cooled on the surface of the earth? By what agencies is the third class of rocks formed? What is the state of clay when heated but not melted? Are igneous rocks ever forced up through the stratified rocks? What are these called? What would have been the position of all stratified rocks if no volcanoes had ever existed? How high have

mountains been thrown up? How was much of the present dry land once situated? How is this known? What is the name of rocks that contain organic remains? Describe the classes of rocks in the note. Organic remains.

LESSON II.

MINERALS.

Having told you something about the formation of rocks, I now proceed to speak of minerals. A *mineral* is a natural production, formed of particles of matter. These particles are organized in certain forms, when becoming hard or solid, by a power called *crystallization*. A *simple* mineral is a substance having the same appearance in every part. It is not a simple *substance*, but when analyzed may be reduced to several elements.

The number of simple minerals has been computed as no less than four hundred and thirty-four. Nearly fifty of these are *metals*. But exclusive of the metals, *nine simple minerals* constitute, probably, nineteen-twentieths of the solid part called crust of the globe. These have been appropriately denominated the ALPHABET OF GEOLOGY. When a knowledge of these has been obtained, and of their combinations to form rocks, the learner will be able to spell and read most of the rocks existing in this or any other country. By the analysis of these, furnished in Part I. and Part II., he will be able to apprehend their relation to the soil, and the most important vegetable products of the earth. This knowledge may be acquired by any intelligent child, ten or twelve years of age, in a *few months*, and will be more useful than most other studies occupying an equal amount of time.

The first letter of the geological alphabet is *quartz*. Pure quartz, when analyzed, is found to consist of ninety-five parts of silex (frequently written silica) and five parts of water. All minerals of which quartz forms an essential part are called silicious. Quartz is the hardest of the nine simple minerals. It may generally be distinguished from other simple minerals by two tests: it will scratch glass, and strike fire with steel. Most varieties have a resinous or glassy appearance, and may, by a little use, be distinguished readily by the eye. The predominant color is white or whitish, but many varieties are red, yellow, smoky, green, and sometimes nearly black.

QUESTIONS ON LESSON II.

What is the subject of this lesson? Describe a mineral. By what power are these particles organized? What do you understand by a simple mineral? Is it a simple substance? How do you know it is not? How many simple minerals? How many are metals? What proportion of the crust of the earth do nine simple minerals compose? What name is given to these minerals? When you have learned this alphabet, what can you read and spell? What may you learn by their analysis? Is this study important? What is the first letter of the geological alphabet? Of what ingredients is pure quartz composed? What is meant by silicious minerals? How may quartz be distinguished from other simple minerals? What predominant or principal color has quartz? Of what other color is it sometimes found?

LESSON III.

VARIETIES OF QUARTZ.

THE names of the more usual varieties of quartz are the following: **Greasy** quartz, which is light colored, and looks as if the surface had oil on it. **Milky** quartz is as white as milk. **Smoky** quartz has various shades, from a light to a dark smoky color.

Ferruginous quartz has some shade of yellow, produced by a small amount of iron. **Blue** quartz is readily known by its name. **Rose red** quartz is also readily distinguished by its name; the color is owing to a trace of manganese. **Limpid** quartz is transparent like ice.

Granular quartz exhibits small granular concretions or grains, and has not much lustre or transparency. It is usually white, or yellowish white.

Tabular quartz occurs in tables, with their flat surfaces united; sometimes this variety resembles scales.

Irised quartz reflects colors similar to the iris of the eye or the rainbow.

Aventurine quartz exhibits various colors, and is variegated by brilliant points or spangles, which shine with a silver or golden lustre.

Prase is green quartz, and is often very beautiful.

Arenaceous quartz consists of loose grains, coarse or fine, angular or rounded. It sometimes occurs in the form of sand, and at others the grains have been united so as to form sandstone. Quartz often occurs in the form of crystals, and is then called *rock crystal.* The usual form is a six-sided prism, terminated by a six-sided pyramid. More generally this termination is seen only at one end, while the other is attached to a part of the rock not crystallized. Quartz crystals are usually limpid, but sometimes smoky, or amethystine purple.

Drusy quartz is a variety of very fine crystals, exhibiting only the pyramidal termination. Hundreds of these may often be formed on a square inch of surface. This variety is often very beautiful.

Amethystine quartz has a violet-blue color, and when crystallized is one of the precious stones mentioned in the Bible.

QUESTIONS ON LESSON III.

Describe greasy quartz. What color is milky quartz? What is said of smoky quartz? How may ferruginous quartz be distinguished? By what is blue quartz readily known? From what does rose quartz derive its color? What does limpid quartz resemble? How does granular quartz differ from other varieties? Of what color is it? What variety occurs in tables? What does it often resemble? Which variety reflects colors like the rainbow? What are the peculiarities of aventurine quartz? What other name has prase? Of what does arenaceous quartz consist? In what forms is it found? When quartz occurs in the form of crystals, what is it called? What is the usual form of these crystals? Is this termination seen at both ends? Of what colors are quartz crystals? What do you understand by drusy quartz? How many crystals are often found on a square inch of surface? What is the color of amethystine quartz? What does it form when crystallized?

LESSON IV.

MINERALS PRINCIPALLY QUARTZ.

Many other minerals are composed principally of silex, and are spoken of in the Bible and other books as *precious stones*. Several of these are not only very beautiful, but are highly valued by jewellers, who employ them as ornaments for gold rings, seals, brooches, etc.

Chalcedony is a variety of quartz, named from a town in Asia Minor. It has usually a whitish color, but of several shades, and has a lustre nearly like wax. When polished, it is very beautiful and valuable.

Agate is a variety of chalcedony. The colors are arranged in stripes, or waves.

Onyx Stone is another form of striped chalcedony.

Carnelian stone is a flesh-colored variety of chalcedony; some specimens are nearly blood-red.

Chrysoprase is green, and often has stripes, with lighter and darker shades.

Sard is a brownish-red variety of quartz.

Opal is principally silex, of a delicate yellowish white. **Fire Opal** presents bright hyacinth-red and yellow reflections.

Sardonyx differs but little from carnelian, being usually reddish yellow or orange.

Plasma is usually some shade of green, varying between leek and grass-green.

Silicious Sinter is a porous variety resembling chalcedony. It occurs in stalactite masses, and is sometimes mammillary and globular. It has a pearly aspect. Its color is white, gray, and sometimes inclining to red, or yellow.

Hyalite and **Michaelite** are varieties of silicious sinter; the latter containing sixteen per cent. of water.

Heliotrope is green, with blood-red or yellowish spots. It is employed in jewelry.

Flint is very hard, usually found in chalk-beds, in rounded masses, and was formerly extensively employed for making gun-flints. It is principally silex, with one or two per cent. of lime, alumina, and water.

Hornstone has the appearance of horn, and hence its name. It is not quite so hard as common quartz, and exhibits a splintery fracture. It never has the lustre of common quartz.

Jasper is not usually quite so hard as quartz, but will give sparks with steel. It has a conchoidal fracture. Its colors are various, — red, red and white, and sometimes black. Many specimens are very beautiful, and are classed with precious stones.

Buhr-stone is porous, and has a greater or less number of cavities, which, with its hardness, render it valuable for mill-stones. Its color is gray or grayish-white, but sometimes it has a shade of blue or yellow.

QUESTIONS ON LESSON IV.

Are other minerals composed of silex? What is said respecting these? For what purposes are they employed? From what does chalcedony derive its name? Describe it. When is it valuable? What is agate? How are the colors arranged? Describe onyx-stone. How is carnelian stone distinguished? Describe chrysoprase. Of what is sard a variety? What color has it? What is the principal ingredient of opal? Describe fire opal. How does sardonyx differ from carnelian? What color has plasma? What does silicious sinter resemble? In what forms is it found? What are its colors? What varieties of silicious sinter are mentioned? How much water does michaelite contain? Of what color is heliotrope? For what used? How is flint generally found? For what employed? What are its ingredients? How does hornstone derive its name? Is it hard as common quartz? What is said respecting its lustre? Describe jasper. What are its colors? Is it classed with precious stones? What peculiarities has buhr-stone? How is it used? What color has it?

LESSON V.

VALUE AND USES OF QUARTZ.

QUARTZ, or silex, is not only highly valuable as furnishing a large number of most beautiful cabinet specimens, and for ornamental work, but it enters largely into the composition of many important rocks. It is also of the greatest value in the arts, being an essential ingredient in all the varieties of glass, not only for lighting our houses, etc., but for the formation of many most important philosophical instruments. The telescope, microscope, magic lantern, and spectacles, both for the near-sighted and for those whose vision is weakened by age, could not be made without it. The glass ware for domestic purposes, and crockery ware of all varieties, could not be formed without quartz. It is an equally essential ingredient in brick, and also in the mortar used for plastering buildings, constructing brick and stone walls, and erecting chimneys.

No mineral or metal except iron is so necessary and useful to man, and no other is so abundantly and universally supplied. It is supposed to compose nearly half of the solid substance of the earth. It is a constituent part of all good soil, and aids in the formation of the stalks of most vegetables, and is essential to the formation of most seeds, as well as grain or corn. Every person, therefore, ought to know something about this first letter of the geological alphabet.

QUESTIONS ON LESSON V.

What is the first important use of quartz mentioned in this lesson? Does it hold an important place in connection with the arts? In what articles of importance is it an essential ingredient? Mention other examples of its usefulness. Is quartz very necessary and useful to man? Is it found in abundance? How large a proportion of the solid substance of the earth is composed of silex or quartz? Of what is it a constituent part? What part of vegetables does it aid in forming? Is it essential to the formation of seeds and grain? Is it important that all should learn something about quartz?

LESSON VI.

FELDSPAR.

The second letter of the geological alphabet is **Feldspar.** This simple mineral is most usually white, but often flesh-colored, and sometimes blue or green. It has more lustre than quartz. It is not quite so hard as quartz, though some varieties will scratch glass and give sparks with steel. It is composed of silex sixty-four to seventy per cent., alumina seventeen, potassa thirteen, lime three, and oxide of iron one. These proportions vary in different specimens. But silex, alumina, and potassa are always prominent ingredients. It has generally a crystalline structure, and one variety has a perfectly crystalline form. The usual form of the crystals is an oblique prism, whose sides are unequal, and vary in number from four to ten. The different varieties are known by different names.

Common feldspar usually occurs in masses or fragments combined irregularly in granite and some other rocks. It has a vitreous or glassy lustre, and may be easily distinguished by the eye after a little practice.

Green feldspar varies from common mostly by its color. This variety is not very common, but is very beautiful. It is highly valued by lapidaries. It is sometimes called **Amazonian** stone, from the name of the river Amazon, on the banks of which it is found in considerable quantities.

Adularia is crystallized feldspar, and bears the same relation to common feldspar that rock crystal does to quartz. Its usual color is milky-white, but sometimes has a shade of gray, yellow, green, or red. It often reflects the colors of the iris. Some specimens are translucent, and others nearly transparent. Adularia has a strong pearly lustre. It has received various names from lapidaries, as *fish's eye*, *moonstone*, *sunstone*, and *ire-spar*. Some specimens are very highly valued.

Silicious feldspar occurs in laminated masses, and in thin rhombic tables, the edges of which are often laminated. The color is white, and often shining, or pearly. It is translucent, and sometimes transparent. It is a little harder than common feldspar, having about seventy-one per cent. of silex. Instead of potash, it contains nine or ten per cent. of soda.

Albite is a beautiful variety, differing but little from silicious feldspar. It is usually marked with striæ, often diverging, and sometimes very wide. Its usual color is white.

QUESTIONS ON LESSON VI.

What is the second letter of the geological alphabet? What is its color? Has it any lustre? What is said respecting its hardness? Of what ingredients is it composed? Are these always uniform? What is the common structure of feldspar? Describe the crystals. How does feldspar usually occur? What is said of its lustre? How is green feldspar distinguished from the common variety? Is it valuable? By what other name is it known? Why is it thus denominated? What name is given to crystallized feldspar? What can you tell respecting this mineral? What are its colors? Has it other names? What are they? How does silicious feldspar occur? Of what color is it? Mention other facts respecting it. What is albite? How is it usually marked? What is its color?

LESSON VII.

FELDSPAR — VARIETIES AND USES.

Glassy feldspar has a highly vitreous lustre. Its color is grayish-white. It is usually crystallized in four-sided prisms, terminated by dihedral summits. **Ice-spar** is also a beautiful variety of feldspar. The crystals resemble ice. It does not vary much from some varieties of glassy feldspar.

Opalescent feldspar is a beautiful variety, reflecting light of different colors. It is gray, or blackish, or yellowish gray, often marked with spots or grains. Its structure is foliated. When held in certain positions, it reflects a beautiful play of colors, green, blue, yellow, red, and brown.

Petuntze is a variety of feldspar from which porcelain ware is manufactured. When decomposed it appears like whitish clay, but does not vary very much from common feldspar. After decomposition, it has lost its potash, and is composed principally of silex and alumina.

Kaolin is decomposed feldspar. The potash or soda contained before decomposition is essentially lost, and must be supplied by lime, or some other flux, when employed in forming porcelain ware.

Its color is grayish white, often with a shade of red or yellow. It is of great importance.

Feldspar is always found in granite, gneiss, and porphyry. It seldom forms extensive beds, but is quite often found between layers of carbonate of lime and some other rocks. At West Chester, New York, these beds are sometimes three or four feet thick.

The uses of feldspar are various and important. It forms a constituent of many important rocks, and, when decomposed, furnishes potash and soda to the soil. Lapidaries employ it for their work, for setting in rings, forming beads, etc. But its highest uses are in the formation of the most beautiful and perfect porcelain and China ware, and also mineral teeth. Kaolin forms the body of the vessel, and petuntze is employed for the enamel, or glazing.

With this letter of the geological alphabet every one should become sufficiently familiar to be able to distinguish feldspar from the other minerals which enter into the composition of rocks, and to understand the meaning of the terms employed with reference to it.

QUESTIONS ON LESSON VII.

How is glassy feldspar distinguished? Its color? What is the usual form of its crystals? Whence does ice-spar derive its name? What variety of feldspar does it strongly resemble? Describe opalescent feldspar. What are its colors? Its structure? What more can you say of it? What is petuntze? How is it employed? What does it resemble when decomposed? What are its ingredients after decomposition? What do you understand by kaolin? By what must the potash be supplied which is lost by decomposition? What color has kaolin? What is its importance? In what minerals is feldspar always found? Mention other facts respecting it. Of what is it an important constituent? What is its value when decomposed? For what ornamental work is it employed? How is kaolin most extensively used? Is a knowledge of feldspar of much importance?

LESSON VIII.

MICA.

The third letter of the geological alphabet is **Mica.** This is one of the most easily distinguished minerals, from the fact that it is composed of thin plates, or laminæ, — very easily separated, and usually very elastic. The laminæ are so thin that many hundreds, placed one upon another, would not make the thickness of an inch. The color varies from pearly-white, violet, brown, green, and smoky, to black. Mica is so soft it may be scratched with a knife, and thin laminæ cut with delicate scissors.

The light-colored varieties are nearly transparent, and have been employed instead of glass for windows and lanterns.

Mica is composed of silex, forty-five to fifty, alumina, thirty to thirty-five, potash, eight to nine, with one or two per cent. of manganese, fluorine acid, and water.

Iron enters quite largely into the black variety, occasionally to fifteen or twenty per cent. But in most varieties there is only one or two per cent. The more common form of mica is in small laminar folia, collected in masses, or disseminated in other minerals.

Prismatic mica is a beautiful variety. The laminæ are usually divisible, parallel to their edges, into minute prisms. Frequently all the colors of the rainbow are reflected.

Hexagonal mica occurs in six-sided prisms. The lustre is pearly, and sometimes sub-metallic. The color is generally green, or greenish brown. This variety often contains a large portion of magnesia, more than a fourth of its weight.

Green mica varies from other varieties principally by its color. Light-green occurs in large plates, but the darkest green in very small scales.

Plumous mica exhibits small scales so arranged as to have the appearance of a feather. Hence its name.

Lepidolite mica is composed of small scales, forming a mass, — usually rose-red or gray, — and is distinguished from other varieties, by containing lithia from four to seven per cent.

Silver mica is often found combined with quartz, and has a beautiful lustre. Large plates of mica, more than a foot in length, are sometimes found, and are useful for lanterns, and the windows of ships of war, where glass would be easily broken. It is employed in stoves, as windows, to give light from the fire. It is not easily fused or melted, and may be used where glass could not.

Mica enters into the composition of many rocks, and is found almost always present, more or less abundant in all the older rocks. When found in sand, where a small quantity of iron is combined, it is often mistaken by the ignorant for gold-dust.

QUESTIONS ON LESSON VIII.

What is the third letter of the geological alphabet? Is it easily distinguished? How thick are the laminæ or plates of which it is composed? What are its colors? Is it very hard? For what purposes are some varieties employed? What are the ingredients of mica? What is said respecting the black variety? Most common form of mica? Describe prismatic mica. How does hexagonal mica occur? What its lustre? What is the common color? Mention any facts respecting it. How is green mica distinguished? In what forms does it occur? Describe plumous mica. Of what is lepidolite mica composed? Its color? How distinguished? What can you tell respecting silver mica? Other facts respecting mica? What are its uses? Is it easily melted? What mistake is often made respecting mica? Does it enter into the composition of rocks? Where is it almost always present?

LESSON IX.

CARBONATE OF LIME.

The fourth letter of the geological alphabet is **Carbonate of Lime.** The preceding letters are earths. This and the following one are chemical salts. An earthy or metallic base, combined with an acid, is what chemists denominate a **Salt.** Carbonate of lime consists, when pure, of fifty-five to sixty per cent. of lime, and forty to forty-five of carbonic acid. It is more important and more abundant than any other simple mineral except quartz. It is not so hard as either quartz or feldspar, and may be easily distinguished from them, and most other minerals, by effervescing when sulphuric or muriatic acic is dropped on it. All the varieties of this mineral are called **calcareous,** from calcium, the metallic base of lime. **Limestone** is the common name of every variety, and **Marble** of all those varieties which receive a good polish.

Limestone has a great variety of colors, from the most perfect white to nearly jet-black, and is often dove-colored, clouded, and flesh-colored. Many of the varieties of limestone were formed since there were plants and animals upon the earth, and contain many kinds of organic remains.

Trees, plants, shells, fish, lizards, and even quadrupeds, are found in a state of petrifaction. Many of these are so perfect, that they may be easily classified by naturalists who are able to distinguish them into orders and species as readily as if the living vegetables or animals were exhibited. The history of ancient vegetables and animals is thus printed on the rocks, and will continue to be read in all future ages.[1]

Carbonate of lime is found both crystallized and amorphous. The form of the crystals is various, but generally some variety of rhomb, with angles obtuse, and very obtuse, acute, and very acute. In some cases, a six-sided prism, and in others a twelve-sided, called a dodecahedral, occur. The form of the crystals varies, often in the same hand specimen.

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[1] See Palæontology.

Rhomb spar and **Dog-tooth** spar may be found associated together. Crystals are not unfrequently compound, and exhibit different beautiful forms. But it does not accord with the limits or plan of this work to detail these at length. Crystalography must be studied by the aid of a much more extended treatise.

QUESTIONS ON LESSON IX.

What is the fourth letter of the geological alphabet? What are the preceding letters called? What is this letter? What do you understand by a chemical salt? Of what does pure carbonate of lime consist? Is it an important mineral? How may it be distinguished from nearly all minerals? What name is given to all the varieties of this mineral? Whence is the name derived? What is the common name? What is marble? Name the colors of limestone. How recently were some varieties of limestone formed? What do they contain? What petrifactions are found in limestone. What interesting fact is mentioned respecting these? What is printed on the rocks? In what forms does carbonate of lime occur? Form of the crystals? Do they vary in form? What varieties are sometimes associated together? What more can you tell about crystals? How must crystalography be studied?

LESSON X.

VARIETIES OF CARBONATE OF LIME.

AMONG the varieties of carbonate of lime, the following may be specified: —

Calcareous spar. This has a great variety of forms, and exhibits various aspects. It is usually purer than other varieties of limestone. It contains about fifty-six per cent. of lime, and forty-four of carbonic acid. **Iceland** spar is nearly transparent, and exhibits different forms of crystals, generally rhombs. **Satin** spar is composed of minute fibres, having a delicate satin lustre.

The varieties of limestone are very numerous. Names are frequently given to different varieties from the place where they were discovered, as Stockbridge limestone, Chazy limestone, Trenton limestone, Baltimore marble, Italian marble, Irish marble, etc. Others receive names from the color of the stone, as **Dove** marble, **Black** marble, **Clouded** marble, **Breccia** marble, etc.

Stockbridge marble is usually white, or nearly so.

Dove marble is so called from the bluish shade it exhibits when polished.

Trenton, or encrinite limestone, contains petrifactions of coral.

Shell limestone is composed, more or less, of the shells of sea-fish.

Statuary marble is that variety which is sufficiently compact and uniform in texture to admit of being wrought into statues, and highly polished. It is, therefore, more highly valued than most other varieties.

Dolomite marble contains a considerable portion of magnesia, and does not receive so high a polish as many other varieties. It has the peculiarity of being flexible, or bending, by its own weight, when sawn into tables, or slabs, and these are suspended by the ends.

Calcareous tufa is a porous limestone, which has been deposited from springs, highly impregnated with carbonate of lime. It is full of cavities, and, frequently, leaves, twigs, and petrified moss.

Stalactite is a formation from lime, usually formed on the roofs of caverns, in the shape of icicles. **Stalagmites** are masses at the bottom of caves, formed by the dropping of water from stalactites. **Shell** marl is formed of snail and other shells.

The uses of limestone are various and important. Marble can be sawed into blocks, slabs, or tables, and is thus fitted for monuments, gravestones, etc., or for window caps, or other parts of buildings. It is also employed for ornamental purposes, as jamb or hearth stones, floors, tables, etc. Many of the clouded varieties are highly beautiful.

Irish or **Golden** marble exhibits streaks of yellow in black.

Breccia marble is a variety composed of angular fragments, of various colors, cemented together.

No other stone answers a good purpose for statuary, or for lithograph printing. The latter use has become very highly important as a means of supplying illustrations of many things in science, art, etc., much cheaper than could be done by copper or steel-plate engravings.

QUESTIONS ON LESSON X.

What is the first variety of carbonate of lime mentioned in this lesson? What is said respecting it? What are its ingredients? Describe Iceland spar. Of what is satin spar composed? Are there many varieties of limestone? From what are they often named? Give examples of this. In what other manner do they acquire names? Mention several varieties. Describe Stockbridge marble. Whence does dove marble take its name? What does Trenton limestone contain? Of what is shell marble composed? Define statuary marble. What is said of its value? How is dolomite marble distinguished? What peculiarity has it? Can you describe calcareous tufa? What is stalactite? What the origin of stalagmites? From what is shell marl formed? Mention the uses of marble. For what ornamental work is it employed? How is Irish marble marked? Of what is breccia marble composed? What two important uses of limestone are mentioned? Why is it specially valuable for lithograph printing?

LESSON XI.

CARBONATE OF LIME — ITS USES.

When carbonate of lime is subjected to strong heat in a kiln for two or three days, the carbonic acid is removed, and it becomes quick-lime, in which state it is suitable for a strong cement or mortar, if combined with sand and water in proper proportions. No other substance would answer equally well for plastering rooms, laying brick and stone walls and chimneys. A variety, known as **Water** or **Hydraulic** cement, sets or hardens under water, and becomes nearly as solid as stone. It is used for making tanks or cisterns for holding rain-water.

Caustic lime is of great importance in agriculture by supplying the lime which enters largely into many of the most useful plants. Without a supply of lime in the soil, many vegetables could not come to perfection. — (*See Soils*, *Part III.*)

Some varieties of limestone contain large proportions of silex. Silicious limestone is difficult to burn into quick-lime, and does not swell much in slaking. But such lime is very valuable when applied to the soil.

The corals of the ocean and shell marl, forming the bottoms of many ponds, are nearly pure carbonate of lime, and can be burned into the best quality of quick-lime. Much of the sandstone in the vicinity of the great lakes contains a considerable portion of lime. This is equally true of some clay slates, Utica and Hudson shales. Very small quantities of lime are found combined with most other minerals. About one-eighth of the crust of the earth is carbonate of lime.

Limestone, suitable for burning, is more or less abundant in all parts of the world, so that people can obtain a supply without great expense.

QUESTIONS ON LESSON XI.

What effect is produced by heating lime in a kiln? What does it become? For what is it then useful? Will any other known substance answer as well for these uses? What is said respecting water lime? Its use? Of what value is caustic lime? What evils would result from a deficiency of lime in the soil? Is silex ever found in limestone? What fact is mentioned respecting silicious limestone? For what is it very valuable? Of what are coral and shell marl chiefly composed? To what use can they be applied? What ingredient is found largely in some sandstone and clay slates? How large a proportion of the crust of the earth is carbonate of lime? Is it so distributed as to be available in nearly every place?

LESSON XII.

SULPHATE OF LIME.

THE fifth letter of the geological alphabet is **Sulphate of Lime,** or gypsum, known also as plaster of Paris. This mineral contains only thirty-two per cent. of lime, to forty-six of sulphuric acid and twenty of water. It is, of course, not hard like carbonate of lime, but may be cut with a knife, and some varieties scratched with the finger-nail. Like carbonate of lime, it has many shades of color, — white, gray, flesh-red, honey-yellow, blue, and impure varieties are sometimes nearly black. It crystallizes in the form of right rhomboidal prisms, but is more generally amorphous, or not crystallized.

Selenite is transparent, and separated easily into laminæ. Sometimes it is *fibrous.*

Alabaster is a fine, massive variety, that has a considerable lustre when polished. When sufficiently solid, it is easily wrought into candlesticks, vases, and other useful articles.

Snowy gypsum is a white variety. **Fibrous** gypsum is often radiated. These and selenite furnish beautiful cabinet specimens.

Gypsum occurs in beds or strata of considerable thickness, and is easily quarried. It is used for many important purposes. After being subjected to heat somewhat greater than boiling water, it is easily ground to a powder, and, after being mixed with water to the consistence of pottage or thin paste, may be turned into moulds of any form, and will in a few minutes become hard and retain the shape of the mould. Its most important use is to form moulds for casting stereotype plates, taking casts of statues, medals, etc., and forming busts. It is frequently used to form a hard finish on walls, and also in the manufacture of artificial marbles. When employed as a manure for increasing the productiveness of all lands deficient in either sulphuric acid or lime, it is invaluable. Being easily ground fine as meal in any common mill, in that state it can be sown broadcast on lands, or combined with compost. Pasture lands, which cannot be ploughed, are often doubled in productiveness.

Anhydrite is a variety composed of about forty-two per cent. of lime and fifty-eight per cent. of sulphuric acid. It is quite as valuable for agriculture as plaster of Paris, but much less common. *Anhydrous* means without water.

The expense of manufacturing books is very greatly diminished in consequence of the adaptation of sulphate of lime to form moulds for stereotype plates. Many editions may be printed from the same plates, and when these plates are worn out the type metal may be recast with comparatively little loss. The value of this mineral to the world can hardly be over-estimated.

QUESTIONS ON LESSON XII.

What is the fifth letter of the geological alphabet? By what other name is it known? What are its ingredients, and what per cent. of each? What is said of its hardness? Of its color? Name some of them. Of what color are impure varieties? In what form does it crystallize? How does it more generally occur? What can you say of selenite? Describe alabaster. What use is sometimes made of it? What is snowy gypsum? Describe fibrous gypsum. What is said of these and selenite for cabinet specimens? In what form does gypsum occur, and what is its use? After being subjected to a certain degree of heat what may be done with it? What is its most important use? How else is it used? What is said of it as a manure? Does it have any effect on pasture-lands? Describe anhydrite. What is its value for agriculture? What is the meaning of anhydrous? How does the adaptation of this mineral to making moulds affect the expense of manufacturing books? Can more than one edition be printed from the same plates? When they are worn out what may be done with them? What is said of the value of this mineral to the world?

LESSON XIII.

CLAY.

THE sixth letter of the geological alphabet is **Argillite**, or clay, of which alumina is the base. Common clay and clay slate do not differ much in their analysis. Pure clay consists of silex about forty-eight per. cent., twenty-three per cent. of alumina, five of potash, eleven of iron, seven or eight of water, and a trace of manganese, sulphur, and carbon. Much of the clay slate of Vermont, especially on the east side of the Green Mountains, contains several per cent. of lime. Both clay and clay slate will vary considerably when analyzed, being affected by the character of the rock in place when it was deposited, or formed.

Argillite, or common argillaceous slate, exhibits many varieties of colors. Some strata are gray, with a shade of blue. Others have shades of green, reddish or bluish black. It is capable of being split into thin plates, and is chiefly employed for writing and roofing slates. For both of these purposes it is of great value. It is sometimes employed for building stone, and was formerly wrought considerably for gravestones, where marble was not easily obtained. It is sufficiently soft to be cut with a chisel or scratched with a knife.

Argillaceous slate usually occurs in thick strata. It is sometimes found associated with talcose slate, and at other times with novaculite, or aluminous slate. Organic remains of fish, trilobites, and plants are frequently found in argillaceous slates.

Novaculite slate, or **Turkey Hone Stone,** usually contains a greater amount of silex, and hence is more valuable for hones, whetstones, etc. It contains about seventy per cent. of silex, fifteen of alumina, eight to ten of iron, and three of water. Vast beds of this valuable mineral occur in the north-east part of Vermont; also in Maine and Massachusetts. A quarry that has been opened on an island in Memphremagog Lake is unsurpassed in excellence by any brought from Turkey, and known as Turkey hone stone.

QUESTIONS ON LESSON XIII.

What is the sixth letter of the geological alphabet? What is the metallic base of this letter? Do common clay and clay slate differ much in analysis? Of what does pure clay consist? What is said of the clay slates of Vermont? Why do both clay and clay slate vary considerably when analyzed? What is said of the colors of argillite, or common argillaceous slate? Is it capable of being split? For what is it chiefly employed? What is said of its value for these purposes? How else is it sometimes employed? What can you say of its hardness? How does this slate usually occur? In connection with what is it sometimes found? What remains are sometimes found in this slate? Describe novaculite slate. Has it any value? What are its ingredients? Where does this mineral occur in vast beds? What is said of a quarry in Memphremagog Lake?

LESSON XIV.

HORNBLENDE.

The seventh letter of the geological alphabet is **Hornblende.** It is almost always crystallized, and the usual form of the crystals is a four-sided prism with rhombic bases, or a six-sided prism terminated at one extremity by four trapezoidal faces. Its specific gravity is greater than that of any of the preceding minerals, being nearly three and one-half times as heavy as water. It is composed of about forty-two per cent. of silex, twelve of alumina, eleven of lime, thirty of iron, twelve to eighteen of magnesia, one to two of manganese, and one to two of water. The analysis, however, varies very much in different specimens, especially with regard to the amount of iron, lime, and magnesia. Most varieties have a strongly metallic lustre. The prevailing color is black, or blackish-brown, or brownish-green. It furnishes a great variety of beautiful cabinet specimens, but is not employed for any very important economical use. It furnishes important elements of soil, and where it has decomposed considerably it is specially favorable to the growth of wheat and herdsgrass.

Common hornblende is often crystallized, but frequently occurs in lamellar and fibrous masses. The fibres sometimes diverge from a centre, and are stellated.

Acicular hornblende occurs in masses composed of acicular fibres or crystals, often diverging in fascicular groups.

Slaty hornblende differs from the former variety principally by a slaty structure.

Corinthian hornblende occurs in black or greenish-black masses, and has a foliated structure and a splendid vitreous lustre. It furnishes beautiful specimens for cabinets.

Actinolite is also a very beautiful variety, varying from the preceding by the presence of three or four per cent. of chrome, which gives it a brilliant green color. Its fibres are sometimes radiated, and sometimes fascicular. Crystals are sometimes of considerable size. It is sufficiently hard to scratch glass, having more silex and less alumina than common hornblende. Actinolite is sometimes massive, sometimes glassy, but more generally fibrous or acicular. It is commonly found associated with steatite or talc, but not always.

QUESTIONS ON LESSON XIV.

What is the seventh letter of the geological alphabet? How does it generally occur? What is the form of the crystals? What is said of its specific gravity? Of what is it composed? In which ingredients does its analysis vary most? What is its lustre? Its color? What is said of it for cabinet specimens? Has it any important economical use? Is it useful to soil? Beside being crystallized, what is a form of hornblende? What is radiated hornblende? Describe acicular hornblende. How does slaty hornblende differ from the former varieties? How does Corinthian hornblende occur? What is its lustre? Describe actinolite. Its color? What is said of its fibres? Its crystals? Its hardness? What is its form? How does it usually occur?

LESSON XV.

HORNBLENDE VARIETIES — CHLORITE.

Tremolite is a variety of hornblende, usually white or light-colored, having a brilliant lustre. The fibres are usually brittle.

Asbestos is a variety of hornblende so different in general appearance from others, that except from analysis it would not be classed with it.

Ligniform asbestos has a strong resemblance to wood, as its name indicates. Its structure is "irregularly fibrous." The fibres are often curved so as to resemble wood formed round knots. Its color is brown, but frequently has a shade of green. Asbestos is never found in very large masses, but in scales or seams on serpentine, and sometimes in other rocks.

That variety known as **Cotton** asbestos is a great curiosity. It is fibrous, soft, and flexible, and may be carded and spun into threads, and even woven into cloth. Its lustre is quite silky or pearly. It has been employed for wicks of lamps, as it may be subjected to a red heat for a long time without any decomposition. The ancients used such cloth, it is said, to wrap around dead bodies before burning, in order to preserve the ashes.

Amianthus is a variety where the fibres are parallel, and have a very delicate pearly lustre, soft to the touch as the finest silk. This variety is found only in narrow veins.

Mountain Cork is a soft, porous variety, and is lighter than water. It is fibrous, and the fibres so cross each other as to form numerous small cavities. It is frequently called **Mountain Leather,** and sometimes rock paper. Its color is usually dull yellow, inclining to brown.

The eighth letter of the geological alphabet is **Chlorite.** This is sometimes crystallized in a six-sided form, but is more generally massive. Its color is emerald or olive green. It can be cut with a knife. It has a vitreous or pearly lustre. It is composed of silex about thirty per cent., alumina seventeen, magnesia thirty-three, iron four or five, and water twelve. It very often contains octahedral crystals of iron, and sometimes specular iron. It is of little value in the arts, but aids in forming extensive strata, called chlorite rocks.

Chlorite rock is easily wrought into door-steps, hearth-stones, etc., but is not extensively employed as a building stone.

QUESTIONS ON LESSON XV.

Describe tremolite. Its lustre. Its fibres. What is ligniform asbestos? Its structure? Its color? How is it found? Describe cotton asbestos. Its lustre. For what is it employed? What use did the ancients make of it? What is amianthus? Its lustre? How does it occur? Describe mountain cork. By what other name is it known? What is its color? What is the eighth letter of the geological alphabet? Describe it. What is its color? May it be cut with a knife? Its lustre? Its ingredients? What does it sometimes contain? Its value? For what is chlorite rock employed?

LESSON XVI.

TALC.

THE ninth letter of the geological alphabet is **Talc.** This is softer than any other mineral; color usually green. It crystallizes in a right rhombic prism, but is more generally foliated or massive. It has a greasy appearance, and when rubbed with the fingers produces a feeling similar to oil. The lustre of talc is usually pearly or shining; often very beautiful. It has more silex than chlorite, often fifty per cent., with thirty-two of magnesia, but only a trace of alumina, and two or three per cent. of water. When perfectly pure it is anhydrous, that is, it contains no water. It is difficult to perceive why it is so soft, while half its weight is silex.

Soapstone, or steatite, is a massive variety of talc, harder than when crystallized or foliated, but when pure is without any sensible grit. It may be cut with an axe or saw without injury to the tool, and is highly useful as a fire-stone for lining furnaces. It will retain heat a great length of time, and is often employed for foot-stoves, ovens, etc. It is now extensively employed for stoves. The ease with which it may be wrought would favor its use as a building stone, but it is too soft for heavy walls.

Rensselaerite is a compact, fine-grained, massive variety of steatite, having fifty-eight per cent. of silex, and thirty-three per cent. of magnesia, with one or two per cent. of water. It is associated with **Pyroxene**, but varies considerably from that mineral in its analysis. It is very frequently found lying in near proximity to serpentine, often on both sides of that rock.

Talcose Rock has a slaty structure, and a shining, greasy aspect. Veins of quartz in this variety are frequently auriferous, and hence this is spoken of as a gold-bearing rock. Most of the gold in the world has been found where the rock in place is talcose. The gold is usually associated with quartz in veins.

QUESTIONS ON LESSON XVI.

What is the ninth letter of the geological alphabet? What is said of its softness? Its color? Form of its crystals? How is it more generally formed? What is its appearance and feeling? Its lustre? Its ingredients? What is it when pure? Describe soapstone. Would it injure an axe or saw to cut it? For what is it useful? How else is it employed? Why may it not be used as a building stone? Describe rensselaerite. Of what is it composed? What is said of it in connection with pyroxene? How is it frequently found? Describe talcose rock. Character of veins of quartz running through this variety? What is the rock in place where gold is found? With what is the gold associated?

LESSON XVII.

ROCKS FORMED OF SIMPLE MINERALS.

A VERY large proportion of common rocks are composed of one or more of the simple minerals, described in preceding lessons; and we may now proceed to some geological spelling.

Quartz, the first letter, of itself forms extensive masses of rock, in veins or strata in the other rocks. Quartz rock is frequently crystalline, and often composed of grains, and is then called granular quartz.

Granular quartz, in some instances, constitutes the principal rock of hills of considerable elevation. Such quartz is often so friable that it can hardly be quarried without crumbling. It is peculiarly valuable for making glass. It is sometimes nearly as white as milk. A locality of this kind at Vernon, and another at Bennington, Vermont, furnish abundant materials for making glass and the manufacturing of stone ware.

Quartz rock is ground in mills, like grain, at Springfield, Vermont, Wilton, New Hampshire, and other places, for the manufacture of sand-paper. This variety abounds in Vermont, and is found in many places in New Hampshire and Maine.

On the borders of several ponds in the north-east part of Vermont, also in New Hampshire and Maine, sand, composed of nearly pure quartz, abounds in large quantities, from which glass to any amount might be made. Most of the sand-banks in the valleys of all the rivers in the north-eastern part of New England contain large amounts of quartz, though not sufficiently free from feldspar and mica to be used for manufacturing glass, but very valuable for making brick and brown earthen ware.

Three letters, quartz, feldspar, and mica, form both granite and gneiss.

Common Granite varies considerably in its appearance. Its usual color is a light-gray, but it is sometimes flesh-colored, and at others nearly black, owing to the colors of the feldspar and mica in it. It is always a crystalline rock, and was formed, doubtless, by heat. When the minerals of which it is composed are in larger masses it is called coarse granite. Plates of mica, several inches in width, and masses of albite or feldspar, several inches in diameter, sometimes occur in granite.

Coarse-grained granite is less useful than when fine-grained for a building stone, as it decomposes with greater rapidity.

QUESTIONS ON LESSON XVII.

Of what are a large proportion of the rocks composed? What may we now proceed to do? What does quartz, the first letter of the geological alphabet, form? Besides being crystalline, of what is it often composed? What does granular quartz sometimes constitute? For what is it peculiarly valuable? Is it sometimes pure white? Where do localities of granular quartz occur? For what do they furnish abundant materials? How and where is quartz rock ground? What abounds on the borders of several ponds in Vermont, New Hampshire, and Maine? What may be formed of it? What do most of the sand-banks in the north-east part of New England contain? Why is this quartz not suitable for making glass? For what is it useful? What do quartz, feldspar, and mica form? Describe common granite, its color, etc. When the minerals of which it is composed are in large masses, what is it called? How large are the masses of mica and feldspar which sometimes occur? What is said of coarse granite?

LESSON XVIII.

ROCKS.

The ingredients of granite vary greatly in the proportions in which they are combined. When mica is in large excess it is called **Micaceous**, and when feldspar predominates it is called **Feldspathic** granite. When feldspar is uniformly disseminated in large crystals, it is **Porphyritic**, Granite may be split more easily in one direction than others. This is owing to the position of the feldspar. When the grains of feldspar and quartz are small, and the rock is compact and free from iron, granite is one of the best building stones that can be used. The combination of iron with granite makes it unfit for this purpose, as it will be discolored and friable.

Gneiss differs from granite only in its structure. It contains more mica, and this is arranged in parallel planes. It is, therefore, easily split into slabs, and seems to be stratified, or at least to resemble stratified rocks. It occurs in beds or tables varying in thickness from a few inches to several feet. The cross fracture is similar to granite. It is very conveniently wrought into jamb-stones, hearths, door-steps, etc., and requires no cutting except on the edges of the slabs. Small specimens of gneiss cannot be distinguished from granite.

Gneissoid granite is intermediate between gneiss and granite. One part of a ledge often seems to be gneiss, and another part granite.

A variety is sometimes spoken of as **Jointed** granite, which, when separated at the joints, presents a smooth and almost polished surface. Jointed granite is, doubtless, the *latest* formed rock in the places where it occurs, as it is often found conformable to the slates through which it has been thrown up. It is finer-grained and less crystalline than other varieties, and often contains fragments of slate embedded in it.

Wherever granite is decomposed, it forms an excellent soil, till the lime and potash in it become exhausted.

Graphic granite is a variety composed of feldspar or albite, and quartz. The quartz is arranged in lines, so that when broken in one direction it has the appearance of oriental writing. Hence its name.

QUESTIONS ON LESSON XVIII.

What is said of the ingredients of granite? When is it called micaceous? When feldspathic? When porphyritic? May granite be split more easily in one direction than another? To what is this owing? When is granite one of the best building stones? How does the combination of iron with it affect it for that purpose? How does gneiss differ from granite? Why is it easily split? How does it occur? For what may it be conveniently wrought? Describe gneissoid granite. What is jointed granite? What is said of the period of its formation? Why is it supposed to be the latest rock? What of its grains and crystalline structure? What does it often contain? Describe graphic granite.

LESSON XIX.

ROCKS — MICA SLATE, ETC.

Two letters, quartz and mica, form mica slate. This rock has a glistening lustre, is usually gray of different shades, and splits into thin slates or layers. Gneiss and mica slate pass into each other, so that it is sometimes difficult to show where the distinction between them begins. This is true of many other rocks, where the varieties approach each other. Mica slate is extensively used for flagging-stones, doorsteps, hearthstones, etc. It is not unfrequently employed for whetstones, and sometimes used as a fire-stone.

Many varieties of mica slate contain garnets, staurotide, tourmalines, and other minerals. When quartz greatly predominates, it is called arenaceous mica slate, and from this it passes into quartz rock.

Two simple minerals, quartz and clay or **Argillite,** form *roofing* and *writing* slates; also, most of the beds of clay abounding in nearly all towns.

Clay, or argillaceous slates, form extensive strata in this and other countries, and, where the laminæ are of suitable thickness for making roof slate, are highly valued. Most buildings in cities are covered with this kind of slate. When of good quality it is very durable. Writing-slates are found in every school-room.

Beds of clay exist in all towns except those which are too much elevated above the level of the ocean. These deposits were doubtless made when the present dry land was covered with the waters of the ocean. The writer has visited but a single town in Vermont in which good clay is not found, adequate to the wants of the inhabitants; and it is presumed very few in the whole country are deficient in this useful article. Its principal use is for brick and mortar, when mixed with proper proportions of sand. Some varieties will make good brown earthen ware, and potteries for that purpose are very common.

Clay is a highly important material to be applied to sandy or light soils. Many thousand acres, in all the New England States, would be immensely benefited by an application of forty or fifty cords of clay per acre. One very important result would be to make vegetable manures more lasting in their effects. In sandy or porous soils clay will retain more moisture for the use of the growing crops. All sandy soil can be made excellent by adding a sufficient amount of clay and vegetable manure.

QUESTIONS ON LESSON XIX.

What do quartz and mica form? Describe its lustre, appearance, etc. What is said of gneiss and mica slate? Is this true also of other rocks? For what is mica slate extensively used? What do many varieties contain? When is it called arenaceous? What rock is formed by quartz and clay? For what is clay or argillaceous slate used? Where only are beds of clay found? When were the deposits made? What are the principal uses of clay? For what else is clay important? What important result of an application of clay? How else would it benefit land?

LESSON XX.

SYENITE, ETC.

THREE letters constitute **Syenite**, quartz, feldspar, and hornblende. It differs from granite by the absence of mica, the place of which is supplied by hornblende.

In Boston this rock is often called Quincy granite, being quarried in that town extensively as a building stone. The monument at Bunker Hill, the new market-house at Boston, and many buildings in and near that city, are constructed of syenite. The color is usually a dark-gray. It is often harder and stronger than granite, but as the hornblende contains iron, the action of the weather is unfavorable to its clear and beautiful appearance. The surface of walls built with this stone may soon become tarnished, and look as if dirty water had been thrown on them. But for stone abutments, railroad culverts, etc., it is more valuable than granite.

Porphyritic syenite is a variety in which large disseminated crystals of feldspar occur. **Syenitic** gneiss has the same relation to common gneiss that syenite has to granite.

When the proportion of hornblende is unusually large, and the proportions of quartz and feldspar small, syenite is often called hornblende slate. It is not unfrequently difficult to distinguish them.

Aphanite is a variety of syenite where the quartz, feldspar, and hornblende are intimately combined. The fracture is smooth, and the complexion is like horn. It is very tough, and has a greater specific gravity than most syenite. It is not very common.

Feldspar and hornblende constitute an important class of rocks denominated **Trap,** or **Greenstone.** The usual color of greenstone, or trap, is greenish-black, or brownish-black.

It is a volcanic rock, and the ingredients have been so mingled by fusing that they are not so easily distinguished as they usually are in syenite and porphyry.

Trap dikes are found varying from a few inches to several feet in width, cutting the strata of slate, and other stratified rocks. Such dikes are very common in granitic regions.

The matter that now composes the dike was forced up to fill a fissure or cleft in the rocks that had been opened, no doubt, by volcanic power.

As the rocks were not melted, the trap will be found to have penetrated every fissure produced, and to retain its distinct characteristics to the very edge of the other rocks through which it has been thrown. In some instances trap has been thrown up in so large quantities as to flow over the upper surface of the older rocks, and form large masses lying above them. These masses are called **Overlying** rocks. If found in such large masses, the name greenstone is usually applied. Some dikes have considerable carbonate of lime, and a few others are almost entirely fine-grained feldspar.

A variety of hornblende, called **Hypersthene,** is found united with feldspar, and forms an important variety called hypersthene-rock. It varies from syenite by deficiency of quartz. It is very tough, and appears in structure much like gneissoid. The colors are gray, grayish-green, or brownish-green, and sometimes inclining to greenish-black.

This rock is quite common in some parts of New York and Canada.

Hypersthene rock is valuable for a building stone where great strength is required. It is much less common than granite or syenite.

QUESTIONS ON LESSON XX.

What three letters constitute syenite? How does it differ from granite? What supplies the place of mica? Where is this rock called Quincy granite? Why? Of what is Bunker Hill monument constructed? Color of syenite? What of its hardness and strength? What is unfavorable to its beauty? How do walls built of this stone become affected by exposure to the weather? For what purposes is it more valuable than granite? Describe porphyritic syenite. What relation has syenitic gneiss to the common variety? When is syenite called hornblende slate? Are they easily distinguished? What is aphanite? Describe it. What of its specific gravity? Is it common? What is greenstone? Its color? What is said of its ingredients? Width of trap dikes? Where are these common? By what force were these thrown up? What interesting facts respecting them? How was trap thrown up in some instances? What are the masses thus formed denominated? What ingredients occur in some dikes? What is hypersthene rock? How does it vary from syenite? What does it resemble in structure? Its colors? Where is it common? Of what value is hypersthene rock?

LESSON XXI.

TALCOSE SLATE, ETC.

QUARTZ, feldspar, and talc are found united in a rock called **Talcose Granite,** or **Protogine.** When the proportion of feldspar is large, and the rock decomposes rapidly, kaolin is formed, which is employed for porcelain, or China-ware. This is highly valuable, but not very common in this country. It is found quite abundant in South-western Vermont. Quartz and talc form talcose slate. The proportions of quartz and talc vary indefinitely in this class of rocks. When the talc predominates, this slate has a shining aspect, is very soft, and splits into thin laminæ, often almost as thin as clay slate. It is usually green, and often very beautiful. But when the proportion of quartz is larger, the rock is less slaty, and less shining; when very large, the rock seems to vary but little from quartz rock, except that it has a shade of green.

On high lands in Vermont and Canada this rock is, in many instances, filled with veins of quartz to such an extent as nearly to destroy the slaty structure.

Talcose slate, as before stated, is a gold-bearing rock. But it is not of great importance in any other respect. In a few locations it forms a good building stone. Some varieties form a good fire-stone when laid so that the edges of the slate are exposed to the greatest heat.

Some have supposed that serpentine is steatite that has been melted, or subjected to a greater degree of heat. But the analysis varies considerably. Two essential ingredients are found nearly the same in both. These are quartz, or silex, and magnesia. Serpentine rock is not stratified (?), is very hard, and contains several per cent. of chrome, while soapstone, or steatite, has none. The latter rock is employed for lining of furnaces and lime-kilns. It is sometimes employed instead of brick for ovens, and makes excellent jamb and hearth stones, and excellent stoves.

Quartz, feldspar, and chlorite unite to form chlorite rock. The color is green, or greenish-brown. It is less slaty than talcose slate, and is soft whenever chlorite is in excess, but often quite hard when quartz and feldspar are the principal ingredients. The rock is sometimes used for a building stone where other stones are not accessible, but has usually but little value.

Carbonate of lime itself constitutes an important variety of rocks, but has been, perhaps, sufficiently described in treating of the simple minerals in lessons nine and eleven. Its importance cannot easily be overestimated.

Sulphate of lime forms extensive beds, but is not found, in connection with other simple minerals, to form a class of distinct rocks. It has been sufficiently described in lessons twelve and thirteen.

QUESTIONS ON LESSON XXI.

What three letters combine to form talcose granite? When is kaolin formed from it? Is this valuable? What do quartz and talc form? Are their proportions uniform? What is the appearance when talc predominates? Its color? How when quartz is in greater proportion? What is said respecting this rock on high lands in Vermont? Is talcose slate of much value except as a gold-bearing rock? What of some varieties? What have some supposed serpentine to be? Is the analysis the same? What essential ingredients are found in both serpentine and steatite? What essential difference between them? How is this rock often employed? Of what is chlorite rock composed? Its color? How does it differ from talc? Is it hard or soft? Is it of much value? What geological letter constitutes an important variety of rocks? What is said of sulphate of lime?

LESSON XXII.

CONGLOMERATE ROCKS.

Another class of rocks, both extensive and important, cannot be classed with the foregoing. They have been formed by grains or fragments of the older rocks, cemented together, and may be denominated **Conglomerate Rocks.**

When fragments of rocks have been moved by water a considerable distance, the sharp corners, or angles, have been worn off, and they become rounded, or water-worn. Such will be seen in the bed or on the shores of every brook or river. Vast masses of such water-worn pebbles and stones are often thrown together so as to form banks and hills. When this mass has been moved by water a great distance, it has been reduced to sand, and, consolidated, it forms **Sandstone.** If rocks have been broken up by any adequate force, and not moved far from the original strata, the fragments will be angular. When united so as to form rock, **Breccia** is the name applied. Each class of fragments has been formed into extensive beds, or strata.

Conglomerate rocks may have been cemented together either by lime, iron, or silex.

Pudding-Stone is formed of rounded pebbles, cemented together. The pebbles, of which it is composed, are perfectly distinct.

Quartz granite, jasper, greenstone, etc., may be found, side by side, in pudding-stone.

Breccia conglomerate, formed by angular fragments, is frequently very beautiful. These fragments are all alike, in some instances, but more frequently different rocks have been broken up, and then cemented together. When limestone has been formed into breccia by a cement of lime, a most beautiful variety of marble is produced. After being polished, the sides of the angular fragments are well defined. Though as solid as granular limestone, the ingredients of which the mass is composed are perfectly distinct.

QUESTIONS ON LESSON XXII.

What is the subject of our lesson? What do you understand by conglomerate rocks? What results when fragments of rock are moved by water a considerable distance? Where may examples of this be found? What do masses of these pebbles often form? How formed into sandstone? Of what form are fragments of rocks when broken? What is breccia? By what may conglomerate rocks be cemented? Describe pudding-stone. What may be found, side by side, in pudding-stone? What is said of breccia conglomerate? Are the fragments always of the same variety? What is breccia marble? How does it appear when polished? Are the ingredients distinct?

LESSON XXIII.

CONGLOMERATE ROCKS, MILLSTONE-GRIT, ETC.

Millstone grit, used for millstones, is a conglomerate of quartz, pebbles, and sand, firmly cemented. It is less porous than buhr-stone, and less valuable.

In many instances, conglomerate is formed of both varieties of fragments, some water-worn, and some angular. The Potomac marble, of which the columns in the Hall of Representatives at the city of Washington are formed, is a beautiful variety of breccia marble.

Sandstone is composed mostly of quartz sand, but often both mica and feldspar may be seen combined in many strata. The old red sandstone, extensive beds of which exist both in this country and Europe, contains a sufficient amount of iron to give it a reddish color. It was formed by cementing stratified sand, and may be split into slabs or tables with great facility. It is a very valuable building stone, being easily quarried and wrought into any desired form. It is always granular.

New Red Sandstone is a variety differing from the preceding more in age than otherwise. It is, perhaps, softer than old red sandstone, but hardens by exposure to the air.

A fine-grained quartz sandstone is extensively employed for grindstones. In order to be valuable this sandstone should not be very hard. If too hard it will glaze by using, and will not wear the tool sufficiently fast. The best quarries of this variety are found in Nova Scotia.

Sandstone found on the borders of Lake Champlain is more compact than those before mentioned. Some varieties seem to have been subjected to a degree of heat, and are almost vitreous.

Burlington sandstone, though very hard, contains distinct impressions of wave-marks, rain-drops, and fucoides.

Potsdam sandstone is lighter colored, and contains organic remains. The upper layers have considerable lime combined, and are hence called calciferous sandstone.

Variegated sandstones, of Highgate and Swanton, Vermont, can be sawn like marble. These are very beautiful varieties. The quarry at Highgate has twenty to thirty per cent. of lime.

Argillaceous sandstone contains considerable clay, and as the clay increases in proportion, it becomes more and more nearly clay-slate.

Encrinite limestone, oölite, etc., have been formed in a manner similar to sandstone, with this exception, that the particles of lime by which they have been formed were once held in solution in water, and have been deposited, like calcareous tufa, from those waters that had carbonate of lime in excess.

Corals, wood, sea-shells, etc., have been united with the sediment of lime and petrified. Chazy and other limestones are filled with macluria, orthoceratites, and other organic remains.

QUESTIONS ON LESSON XXIII.

For what is millstone grit used? How is it different from buhr-stone? Is conglomerate ever formed of both varieties of fragments? What is Potomac marble? Ingredients of sandstone? Whence the reddish color of old red sandstone? Its origin? Its value? Its form? Difference between old and new red sandstone? Which is harder? For what is fine-grained sandstone used? What result if too hard? Where are the best quarries found? What of sandstone near Lake Champlain? Character of some varieties? What impressions in Burlington sandstone? Describe Potsdam sandstone. What is said of the upper layers? Argillaceous sandstone contains what ingredients? Formation of encrinite limestone? What petrifactions mentioned?

LESSON XXIV.

IGNEOUS ROCKS.

The varieties of rocks already described constitute the principal rocks of the earth, except those which are volcanic.

Igneous rocks have all been fused or melted, and either cooled gradually under great pressure, as they would do when melted in the bowels of the earth; or cooled without pressure, as when thrown out of craters or openings in the rocks. The materials of which lavas are composed depend on the character of the rocks that have been melted where volcanoes occur. If one substance is more general in lavas than any other, it is feldspar. In most instances nearly all the materials of which granite is composed may be found in lava; also iron, hornblende, schorl, olivene, etc.

Lime is a very common ingredient in lava; also alumina and soda, magnesia, potash, and sulphur.

Greenstone is a volcanic rock, compact and heavy, and usually, as its name implies, has some shade of green, inclining to brown or black. It was doubtless cooled under great pressure, and therefore has a crystalline texture. It breaks with difficulty, and is valuable for macadamizing roads. Crystals of feldspar abound in it. It is then called porphyritic trap, or greenstone.

Basalt is a variety nearly resembling some varieties of greenstone, and distinguished from it by having distinct crystals of hornblende or augite. Basalt often contains titaniferous iron, and other minerals.

Basaltic rocks are often columnar, and sometimes seem to be formed of oval masses.

Pumice-stone is porous lava, and is often so filled with air-cells that it will swim in water. These cells are sometimes filled with lime, or other mineral substances, and then the rock is called amygdaloid, and is as heavy as greenstone.

Obsidian is a volcanic glass. It does not differ very materially from glass formed in the slag of furnaces for smelting iron. It has usually a large portion of feldspar.

Volcanic slag is a coarsely porous or twisted lava.

QUESTIONS ON LESSON XXIV.

What do the rocks previously described constitute? What are igneous rocks? In what two ways have they been cooled? On what do the materials of lava depend? What substance most common? What ingredients may generally be found in lava? What others are common? Describe greenstone. Its color? Its texture? Its value? When is it porphyritic? How does basalt differ from greenstone? What ingredients often occur in basalt? Form of basaltic rocks? Describe pumice-stone. When is it called amygdaloid? What is obsidian? What does it strongly resemble? What principal ingredient? What is volcanic slag?

LESSON XXV.

COMBUSTIBLE MINERALS.

Besides the rocks described in the preceding lessons, there is a very important class of *combustible minerals.*

Sulphur is a yellow, combustible substance. It burns with a bluish flame and disagreeable odor. It crystallizes in various forms, but is more commonly obtained in the form of a powder. It abounds in the neighborhood of volcanoes, but occurs also in beds of gypsum, and is often found combined with many rocks and metals. It is employed in medicine, but is most important in the manufacture of gunpowder. Brimstone, sold at the shops, is principally sulphur. It can be easily melted and run into any form desired.

An important class of mineral substances contains carbon, probably derived from wood or vegetable matter. They are all combustible, and some of them are of very great importance.

Amber is, no doubt, a mineralized resin, or gum. It burns with a yellow flame and an agreeable odor. It is composed of eighty per cent. of carbon, seven or eight per cent. of hydrogen, and about the same of oxygen. It is mostly procured from a bed of bituminous coal on the coast of Prussia, but is found in small quantities in many other countries. By friction it can be electrically excited, and was anciently called electron. The word electricity was derived from it.

Copal is sometimes found in a fossil state. It nearly resembles amber, and is equally combustible, but contains less oxygen and more carbon. It has a resinous appearance, and is employed extensively in the manufacture of varnish.

Mineral Tallow has about the hardness of soft wax. Its usual color is white, but it becomes dark by exposure to the air. It is principally composed of eighty-five per cent. of carbon, and about fourteen per cent. of hydrogen, and is found only in small quantities.

Mineral Caoutchouc has a resinous lustre, is of a dark-brown color, and is flexible or elastic, and appears much like vegetable caoutchouc or India-rubber. It consists of about fifty per cent. of carbon, forty per cent. of oxygen, and seven of hydrogen, though some specimens have twelve or thirteen per cent. of hydrogen. Like the preceding varieties it burns readily. It is rare, and not of much value.

Bitumen is found both in a solid form and also liquid. When liquid it is called mineral oil. When solid it is called **Asphaltum**, or mineral pitch. It has a resinous lustre, and, in the solid varieties, has a conchoidal fracture.

Naphtha is liquid, and burns like oil. It is yellow, and becomes solid by exposure. This substance is valued as a lotion or wash for sprains or bruises, and is considerably used for painting, instead of other oil. It may be burned in lamps, and was extensively used by the ancients in embalming the dead.

Petroleum is a fluid bitumen that oozes out of certain rocks in coal formations. When exposed to the air it becomes solid. All the varieties of bituminous substances have been long known. When burned, the odor is very disagreeable. A lake in the island of Trinidad seems to be principally composed of this substance. It boils up in the centre quite hot, but cools toward the shores and hardens. Large quantities of bitumen are found on the shores of the Dead Sea, where Sodom and Gomorrah once stood.

QUESTIONS ON LESSON XXV.

What important class of minerals besides those mentioned in preceding lessons? Describe sulphur. Where is it found? Its use? What is brimstone? What peculiarity in the next class of minerals? From what is the carbon derived? Is this class important? Describe amber. Its ingredients? Where found? What was it anciently called? What word derived from it? How is copal found? Describe it. Its use? Describe mineral tallow. Its color? Its ingredients? What is mineral caoutchouc? Its color, etc.? Its ingredients? Is it common? How does bitumen occur? When liquid what is it called? What when solid? Its lustre and form? Describe naphtha. Its use? How anciently employed? What is petroleum? Where found? What result from exposure? Have these varieties of bitumen been long known? What is their odor when burned? What bituminous lake is mentioned? Describe it. Where are large quantities of bitumen found?

LESSON XXVI.

MINERAL COAL.

Mineral Coal is one of the most valuable substances known. The wood or vegetation of a former age of the world has, by the wisdom and kindness of our heavenly Father, been laid up in store for the necessities of man, in such vast quantities as to serve for fuel for millions of years. All the timber, etc., now growing on the earth would not be sufficient for fuel and other purposes for a single century. But God has provided a supply so abundant that it will not be exhausted, probably, while the world continues.

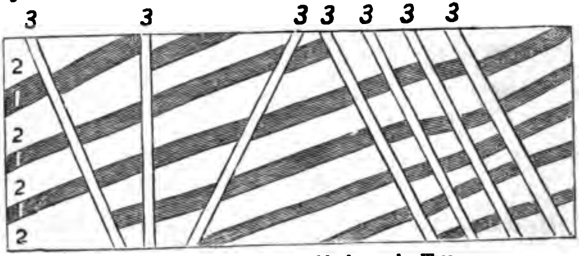
Most of the coal in the United States is the **Anthracite** or blind coal, sometimes called glance coal. Of this variety there are vast beds, as will be seen in the following statements by Professor Edward Hitchcock, one of the ablest geologists of this or any other country.

"The great coal formation of this country consists, like those of other parts of the world, of beds of coal from a mere line to fifty feet in thickness, interstratified with sandstone, shale, and limestone, which constitute the great body of the formation. It is enormously developed in North America. We have first in the north-eastern part of Nova Scotia and New Brunswick a coal-field covering not far from ten thousand square miles. In the south-eastern part of Massachusetts and in Rhode Island is a deposit covering about five hundred square miles." This field, though not much worked as yet, we cannot doubt will be found hereafter to contain important seams of workable coal.

"The great Appalachian coal-field, extending from New York to Alabama, seven hundred and twenty miles in length, covers nearly one hundred thousand square miles." The portion of this field lying in Pennsylvania is very rich, and is extensively wrought. So far back as 1825, more than eight hundred men were employed near the Lehigh in digging this coal. The coal obtained from this mine is generally called Lehigh coal. "The Indiana coal-field, three hundred and fifty miles long, embraces about fifty-five thousand square miles. Another occurs in Michigan, one hundred and fifty miles long, covering about twelve thousand square miles. The Missouri and Iowa coal-fields may be set down at fifty thousand square miles. The grand total, to say nothing of fields yet further west, amounts to more than two hundred and twenty-five thousand square miles, equal to about twenty-eight such States as Massachusetts! If we suppose the average thickness of all the beds to be fifty feet (some single beds are twice that thickness), the whole amount in solid measure of the coal in the United States will be one thousand and sixty-six *cubic miles!* One cubic mile would furnish seven million tons of coal annually for one thousand years. At that rate, our coal would last one million and sixty-six thousand years."

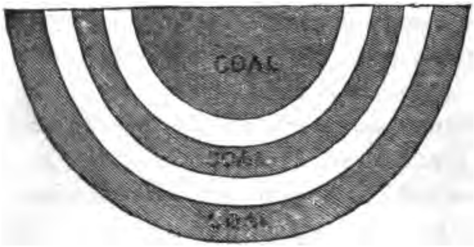
Besides the coal-fields mentioned above, four more have been discovered (two blind coal, and two bituminous) in the vicinity of the Rocky Mountains, but these have not been much explored. An immense bed is reported in Alaska, and others will be found.

The following cut illustrates a coal-field disturbed by volcanic action: —



1. — Strata of coal inclined and broken up by dikes.
2. — Sand-stone and limestone, interstratified with coal.
3. — Dikes disturbing strata of coal.

COAL BASIN.



QUESTIONS ON LESSON XXVI.

Is mineral coal valuable? Its origin? What is said of the wood now growing? Is there danger of the supply of coal ever becoming insufficient? What is the coal of the United States? How is it interstratified? Is there a great supply? Describe the coal-field in Nova Scotia. How large is the deposit in Massachusetts and Rhode Island? Has this been extensively worked? How large is the Appalachian coal-field? Describe the Pennsylvania coal. Number of men employed in 1825? What is this coal called? Describe the Indiana deposit. The Michigan fields. What is stated about other coal-fields? Estimated amount in the United States? Value of one cubic mile of coal? What other fields lately discovered?

LESSON XXVII.

BITUMINOUS COAL.

Bituminous coal seems to be composed in part of bitumen or pitch, and burns with a flame. It contains about a fourth of its weight of carbon, and a few per cent. of nitrogen, with a small proportion of hydrogen and oxygen. The rest is earthy matter. These proportions, however, vary very much in different localities and varieties.

Pitch or Caking coal has this peculiarity, that, when set on fire, it first breaks into small fragments, and then melts into a mass so as to require stirring in order to burn.

Cherry coal appears much like caking coal, but does not cake when heated. It has more nitrogen, and less hydrogen.

Splint coal is harder than cherry coal, and is sometimes called hard coal.

Cannel coal is dark-colored, has a conchoidal fracture, and receives a good polish. It takes fire readily, and burns with a yellow flame without melt-ing. It is sometimes used as a substitute for candles, and from this fact has derived its name.

Jet is a very black variety, resembling cannel coal. It is much less common, but more beautiful. The common phrase, "black as jet," has been derived from the intense black color of this variety.

Lignite or wood coal seems to have been the latest formation. It has very nearly the appearance of charcoal, and burns equally well.

No less than sixty thousand men find constant employment in raising and quarrying coal at Newcastle, in England. Many thousand more are employed in different parts of that country. The coal mines of Great Britain are of immense value to the nation. England would be poor without them.

The other most important variety of coal is called **Anthracite.** This is very hard, and requires considerable heat before it can be ignited or set on fire, but lasts much longer, and is more extensively used. It is composed mostly of carbon, and burns with neither smoke nor flame.

The color of anthracite is nearly black, but, by the presence of a small per cent. of iron, it often reflects all the colors of the rainbow. Such specimens are very beautiful. Anthracite often receives different names from the places where it is quarried, as Susquehanna, Peach Orchard, Lackawanna, etc. It is usually found in beds, from a few inches to many feet in thickness. The amount of anthracite in the world is truly astonishing, as intimated in a preceding lesson.

Graphite or plumbago is composed of from eighty to ninety per cent. of carbon, with eight to ten per cent. of iron. It can be ignited by a high degree of heat, and burns without flame or smoke, but is not often employed for this purpose. It is used principally for making pencils and crucibles, and for polishing cast-iron plates. It is often known by the name black lead, from its color and metallic lustre. It soils the fingers and feels greasy to the touch. Varieties that are perfectly pure command a high price in market.

QUESTIONS ON LESSON XXVII.

Of what is bituminous coal partly composed? Other principal ingredients? Are the proportions uniform? What peculiarity has pitch or caking coal? Describe cherry coal. What is splint coal sometimes called? Describe cannel coal. For what used, and whence its name? Describe jet coal. To what common phrase did its color give rise? What variety of coal was the latest formation? How many men are employed at Newcastle? What is said respecting the coal mines of England? What other important variety of coal? Describe anthracite. Its principal ingredients? How does it burn? Its color? What ingredient causes it to reflect the colors of the rainbow? Different names of anthracite? How does it usually occur? Ingredients of graphite? Could it be used as fuel? Its common uses? By what other name is it known? Describe it. Is it considered valuable?

LESSON XXVIII.

METALS.

The next class of substances, to which attention may be directed, is **Metals.** As the names of many of these are more commonly known, and their uses better understood, the account of them will be very brief.

A metal is a shining, opaque body, having a metallic lustre, and insoluble by water, but fusible by heat.

Metals are good conductors of electricity and caloric. Many are malleable, that is, can be hammered or rolled into plates. Some are ductile, that is, they can be drawn into wire.

A few of the metals are found in a pure or metallic state, but more generally in the state of ores.

A frequent division of metals into malleable and brittle is made; but this is not of much importance.

Several were early known, but many have been discovered within a few years. The whole number now known is less than fifty. Forty-two have been described. Less than half of the known metals are of much value to the world.

The most important malleable metals are platina, gold, silver, mercury, lead, copper, tin, iron, zinc, palladium, nickel, and cadmium. Sixteen others are not capable of being much extended by heat. and are called brittle. These are arsenic, antimony, bismuth, cobalt, manganese, tellurium, titanium, columbium, molybdena, tungsten, chrome, osmium, iridium, rhodium, uranium, cerium.

Potassium, sodium, barium, strontium, calcium, lithium, and some others, have been recently discovered, and were not known till the present century. Platinum, gold, and silver are most valuable by weight.

Platinum is the heaviest of all metals. Its specific gravity is twenty-one and a half, that is, it is twenty-one and a half times as heavy as the same bulk of cold water. (A cubic foot of water weighs one thousand ounces avoirdupois. A cubic foot of platinum would, therefore, weigh twenty-one thousand five hundred ounces. When specific gravity is given, recollect it is the weight of the body compared with an equal bulk of water.) The color is silver-white. It is found only in small quantities. Platinum is so hard to melt that iron and other metals may be melted in a thin cup of it without injury.

It is not, like most other metals, corroded by sulphuric acid. It is principally used for the construction of chemical and philosophical apparatus, but is employed in painting porcelain ware. Its tenacity is so great that it may be drawn into wire not more than a thirty-thousandth part of an inch in diameter. Only a few tons of it have ever been discovered, and this is, doubtless, the reason why its price is so near that of gold. If more abundant it would be much used in the arts. It is a beautiful metal.

QUESTIONS ON LESSON XXVIII.

What is the subject of this lesson? Define a metal. What fact mentioned respecting all metals? What are malleable metals? Meaning of ductile? How are metals more generally found? How are they frequently divided? Have metals been long known? How many are known at present? Are all very valuable? Most important malleable metals? How many and what are called brittle? What metals recently discovered? Most valuable metals by weight? Which is heaviest? Its specific gravity? What is understood by specific gravity? Of what color is platinum? Its hardness? How does it differ from most metals? Its uses? Its tenacity? How much platinum has ever been discovered? Would it be much used if abundant?

LESSON XXIX.

GOLD, SILVER, ETC.

Gold, one of the precious metals, is found both pure and combined with other minerals.

Its color is yellow. Its specific gravity is nineteen and a quarter. It is so malleable that it may be hammered into plates so thin that two hundred and eighty-two thousand would make but an inch in thickness. Its principal value is for coin, but it is very useful for many other purposes. Within a few years the quantity of gold has been vastly increased by the discovery of the extensive mines of California and Australia.

Whether this great increase of the amount of gold in the world will be of any real benefit to man is, perhaps, doubtful, as its comparative value will be diminished. In order to form coin, a small portion of silver and copper is combined with it, to increase its hardness.

When entirely pure it is said to be twenty-four carats fine. The coin that is now made in this country is between twenty-one and twenty-two carats fine, while the English gold coin is twenty-two.

Silver is another of the precious metals, but is worth only about a sixteenth part as much by weight as gold. Its color is white; its specific gravity about ten and a half. Both the ductility and malleability of silver are less than gold or platinum. Its prominent uses are for coins, articles of ware, as bowls, spoons, forks, etc. The bows of spectacles are sometimes made of silver.

When employed for coin, ten per cent. of copper is combined with it to increase its hardness. It is usually found in the state of ore; sometimes, however, combined with gold; often with copper, arsenic, bismuth, and lead. Silver and gold have, for many thousand years, been made the standard of value, and used for coin or money. The principal silver mines in the world are in South America, Mexico, and California.

Mercury is a liquid metal; its specific gravity is about thirteen and a half. It is usually called quicksilver. It becomes solid only by a great degree of cold, seventy degrees below the freezing point. It is employed in the construction of thermometers and barometers. The color is nearly the same as silver. It has a strong affinity for gold and silver, and is often employed to separate them from alloys or ores. It can easily be separated from either of them by heat. It is extensively used for silvering mirrors or looking-glasses. It is also employed in making the medicines called calomel and corrosive sublimate.

QUESTIONS ON LESSON XXIX.

How does gold occur? Its color and specific gravity? Illustrate its malleability. What are its uses? How has its quantity been increased within a few years? Will this increase be greatly beneficial? What metals are combined with it to form coin? Why? How is it designated when entirely pure? Value of gold coin in this country and England? Comparative value of silver? Its color and specific gravity? Its ductility and malleability? Its prominent uses? Why is copper combined with it when employed for coin? How much? How does silver occur? Have silver and gold long been used for coins? Most important silver mines? Peculiarity of mercury? Its specific gravity? Its common name? When does it become solid? Its uses? Its color? Other important uses? What medicines are made from mercury?

LESSON XXX.

TIN AND COPPER.

Tin is usually found in a state of ore, but sometimes in crystals nearly pure. The ore is usually black or brown, but has sometimes shades of gray, red, or yellow, and nearly transparent. It is brittle, and breaks with a fracture subconchoidal. The specific gravity of metallic tin is seven and one-fifth. Tin ore occurs in veins in granite, gneiss, and mica slate. The uses and importance of this metal are well known. Iron coated with it forms what is called tin ware. Combined with mercury, it is employed in making mirrors or looking-glasses. When combined with lead, it forms pewter. Extensive mines of tin have been discovered in Missouri and in California. It is sometimes, when pure, called block-tin.

Copper occurs both native, and in a state of ore, combined with iron, sulphur, etc. Native copper can be employed without preparation, but when found in the state of ore it must be smelted and reduced to its metallic state. It has considerable hardness, is red, and is both ductile and malleable. Besides being formed into coin, it is extensively employed in the arts, for sheathing ships, constructing kettles, etc.

Copper, alloyed with zinc, forms brass, and in that state is extensively used. It is also employed in manufacturing bell-metal. Verdigris is a very poisonous oxide of copper. This metal was known to the ancients before the flood. (See Genesis iv. 22.) The most important copper mines in this country are found in the vicinity of Lake Superior. Smaller mines occur in nearly every State. Its specific gravity is nearly nine.

QUESTIONS ON LESSON XXX.

How is tin commonly found? What is its color? Describe tin. Its specific gravity? How does tin ore occur? How is tin ware formed? Uses of tin? What is pewter? Are tin mines extensive in this country? When is it called block-tin? How does copper occur? How is the ore prepared for use? Describe copper. Its uses? What is brass? Define verdigris. Was copper known to the ancients? Where are the most important mines of this country?

LESSON XXXI.

LEAD, ZINC, AND ANTIMONY.

Lead is an important metal, and very abundant in the state of ore. It occurs both in crystals and masses. A common name is galena.

In its metallic state it is malleable, and so soft as to admit of being cut with a knife. Its specific gravity is eleven. The lustre of galena crystals is brilliant. When formed into sheets, lead is employed for covering houses, and for many other purposes. It is converted into pipe for aqueducts, and is alloyed with tin to form pewter. When strong acids are applied to lead, it is converted into an oxide, and forms a beautiful white paint, so commonly used for the outside of houses. Combined with other paint, it is used for the interior of houses. Immense mines of lead occur in some of the western States. Smaller mines abound in many parts of the country.

Zinc, one ore of which is often called blende, is a metal of considerable importance. Its specific gravity is seven. It occurs both in crystals and amorphous; lustre of the ores somewhat various; colors various, black, brown, yellow, and exhibiting, sometimes, shades of red and green. It is generally associated with lead or galena. When in a metallic state, it is employed for some of the same purposes. It is malleable, but much harder than lead. When made into sheets, it is largely employed to cover flat roofs of houses. Being harder than lead, it melts less easily. It is employed to protect floors from the heat of stoves. When converted into an oxide, it forms a very valuable paint. Many prefer it to white lead.

Mines of zinc are found in many parts of the country. This metal was unknown till the sixteenth century. Calamine is a carbonate of zinc. From this much of the zinc of commerce is manufactured.

Antimony is a brittle metal, of white or light color. The specific gravity is not quite seven. It is usually found combined with sulphur; valuable as a medicine, especially for horses. It is employed with lead for printers' types, and for this purpose is of great value.

QUESTIONS ON LESSON XXXI.

What is said respecting lead? How does it occur? What is galena? Describe lead. Its specific gravity? Lustre of crystals? Uses of sheet-lead? For what is lead used when converted into an oxide? Are lead mines extensive in this country? Is zinc important? Its specific gravity? Describe zinc. Its colors? With what is it usually associated? Is it malleable? For what is sheet zinc employed? Why is it more difficult to melt than lead? What other uses are mentioned? Are zinc mines common? When was this metal discovered? What is calamine? Describe antimony. Its specific gravity? How does it occur? Its value? For what else is it used?

LESSON XXXII.

IRON.

Iron is the most useful of all the metals. It is so important that without it men could hardly advance to a civilized state of society. Generally it occurs in the state of ore or oxide, and is reduced to a metallic state by heat, and the use of lime as a flux.

When fused, it is poured into moulds made of sand, and in this way kettles, stove plates, and castings for many kinds of machinery, are produced. The forms of castings are almost numberless; also the uses to which they are applied.

The specific gravity of iron is nearly eight. Wrought iron is formed by frequent heating and hammering, by which it becomes tough, and capable of being drawn into wire.

Steel, so extensively employed for all edge-tools, is made by baking wrought or hammered iron in an oven with charcoal, by which it becomes a carburet of iron. Bars of the purest iron are placed in an oven with powdered charcoal, and subjected to a high degree of heat for a long time. A small quantity of carbon thus combines with the iron, by which it is made more compact, and capable of being made into edge-tools, springs, and delicate instruments. On plates of steel the finest engravings are made. Iron ores furnish some of the most beautiful crystals of various forms, and are found in a great variety of combinations. A very common form of iron ore is **Magnetic Oxide.** The lustre is submetallic; color iron black; fracture subconchoidal; usually brittle, and strongly attracted by the magnet. The ore beds of Sweden, from which the most valuable iron is manufactured, are generally of this variety. Several counties in New York contain large masses of this variety of ore, especially Warren, Essex, and

Clinton. No variety of ore is more common and more important for the manufacture of good iron.

Specular Iron. The structure is usually lamellar, but it often crystallizes in rhomboidal form. Its lustre is often splendidly metallic. This variety has nearly seventy per cent. of pure iron, and some of its crystals, especially those from the island of Elba, are highly beautiful. The specimens found most generally in this country are in lamellar plates or scales, with a highly polished surface.

Franklinite is a crystallized variety. The forms of the crystals are dodecahedral, or twelve-sided. Lustre is strongly metallic. It is slightly magnetic. In consequence of its crystalline structure, it is easily reduced to grains, and melts with greater facility than some other varieties. It has from sixty-five to sixty-eight per cent. of pure iron.

Hematite of iron has two leading varieties, *brown* and *red*.

Brown hematite occurs usually in stalactite (icicle) form; sometimes botryoidal (grape-like), and often mammillary (breast-like). Some specimens are fibrous and other massive. The lustre is silky, the surface of some specimens highly polished. Hematite has from eighty to eighty-five per cent. of pure iron. Many beautiful cabinet specimens are furnished by this variety of iron ore.

QUESTIONS ON LESSON XXXII.

Which is the most useful metal? Is it very valuable? How does it generally occur? How reduced to a metallic state? By what process are kettles, etc., produced from iron? Are these articles very important? Specific gravity of iron? How is wrought iron formed? How is steel manufactured? What is steel? What is combined with the iron in the process of making steel? Uses of steel? Does iron ever occur in crystals?

Describe magnetic oxide. What extensive beds of this variety? Is it found abundantly in this country? Describe specular iron. How large per cent. of pure iron does it contain? How commonly found? What is franklinite? Form of the crystals? Describe it. Proportion of pure iron in franklinite? What varieties of hematite of iron? How does brown hematite occur? Its lustre? Its proportion of pure iron?

LESSON XXXIII.

IRON, CONTINUED.

Red Hematite is generally massive, nearly the same as specular iron. Some writers include both in the same variety. When scratched with a file the streak is red. It melts easily, and makes soft wrought iron, and is highly valued as an ore for the manufacture of iron.

Spathic Iron is not an oxide, but a carbonate. Its color, more commonly, is ash-gray, but sometimes brown and brownish-red, with a vitreous, pearly lustre. It has about fifty-five per cent. of iron, and thirty six of carbonic acid; and is sometimes called sparry iron. It is very valuable for the manufacture of iron and steel. Most of the immense quantity of iron manufactured in England is from this variety of ore. The iron, however, is not as valuable as that manufactured from magnetic oxide.

Meteoric Iron is a singular variety, that is supposed to have fallen from the heavens. It differs from other varieties by containing nickel. Professor Dana remarks: "One of the most extraordinary of these iron meteorites, preserved in any collection, is now in the Yale College cabinet. It weighs one thousand six hundred and thirty-five pounds; length three feet four inches; height one foot four inches." It has more than ninety per cent. of pure iron, and about eight or nine of nickel. It has been stated that some masses of this singular iron have been found in South America, weighing from sixteen thousand to thirty thousand pounds. Small masses have been found in many countries. Many such have been seen to fall, and by analyzing these, the character of other specimens is readily decided. Meteoric iron must be regarded as one of the greatest curiosities. No philosopher can explain its formation. It can readily be wrought into cutting instruments.

Chromate of iron is a combination of chrome and iron. More than half its weight is green oxide of chromium, and about one-third iron. It occurs only in serpentine rocks. It is very valuable for obtaining chromic acid, from which are formed several valuable paints. The color of the ore is between iron-black and brownish-black. When scratched with a file the streak is brown, by which it may be readily distinguished from other varieties. It never occurs in very large quantities, but is found in many places, so that adequate supplies of it are readily obtained.

QUESTIONS ON LESSON XXXIII.

In what form does red hematite occur? What does it strongly resemble? What is the streak? Is this variety valuable? Define spathic iron. Its color? Its lustre? Its ingredients? Most common variety in England? Is it so valuable as magnetic oxide? Describe meteoric iron. How does it differ from other varieties? Describe a specimen mentioned by Professor Dana. Where and how large have masses of this iron been found? How is it known they fall from the heavens? Is their formation explained? Can meteoric iron be wrought into cutting instruments? What is chromate of iron? What proportion of iron and other ingredients? For what is it valuable? Its color? Its streak? Can it be readily obtained in adequate supplies?

LESSON XXXIV.

IRON, CONTINUED.

Sulphuret of iron, commonly called iron pyrites, is very common. The crystals of it, in the form of cubes, are disseminated in many rocks. Its color is generally yellow, though sometimes nearly white. Many ignorant people often mistake it for gold. From this circumstance it often receives the name of "fool's gold."

It is a compound of sulphur and iron. The proportion of iron is fifty-eight to sixty per cent., and of sulphur thirty-eight to forty. Some varieties are massive, and in this state it is largely employed in the manufacture of green vitriol, often called copperas. The largest manufactory of copperas in the world is at Strafford, Vermont. Massive sulphuret of iron is often combined with a few per cent. of copper.

Sulphate of iron (copperas) is formed of sulphuric acid and iron, and is of great importance in forming black dyes, and also to combine with nutgalls for the formation of good writing-ink. Many varieties of this mineral rapidly decompose when exposed to the air, and rocks containing it are unsuitable for building stones, and should never be employed in laying the foundation for brick houses, or for underpinning.

So much sulphuric acid is produced, sometimes, where rapid decomposition of sulphuret of iron takes place, as to destroy the grass, and for a time produce barren spots. When the sulphuric acid has escaped, such places will be found very favorable to vegetation. A very small portion of this acid is beneficial to soil; but too much is injurious to vegetables.

Bog Iron ore is a variety of brown hematite, formed by iron that has been decomposed, and then washed into low ground, where it remains usually in earthy masses, and generally resting on clay. Its usual color is brown, but sometimes it has a metallic lustre. It is valuable to combine with iron ores that are hard to smelt, and improves the character of iron made from such ore.

Brown Ochre is a variety of this ore. When heated moderately, and pulverized finely, ochre is valuable for a paint. The Spanish brown is made of an earth or clay, combined with a small quantity of oxide of iron. Such paints abound in many places.

Arsenical Iron is a combination of iron and arsenic. It has a metallic lustre, but tarnishes by exposure to moisture. It occurs only in small formations.

When put on a coal of fire, it gives a slight odor of garlic. Arsenic, when pure, is a violent poison.

The varieties of iron are so numerous, that a large cabinet could be formed, and yet no two specimens be alike.

QUESTIONS ON LESSON XXXIV.

What common name has sulphuret of iron? Form of its crystals? Its color? For what often mistaken? Of what is it composed? What are the proportions of each? Form of some varieties? How employed when in this state? Where is the largest manufactory of copperas? What is often combined with massive sulphuret of iron? How is copperas formed? Its uses? Does this mineral decompose rapidly? For what is it unsuitable? What ill effects are sometimes produced by its decomposition? Is any amount of sulphuric acid beneficial to soils? Describe bog iron ore. Its color and uses? What is brown ochre? Its value? How is Spanish brown made? What is arsenical iron? Its lustre? What peculiarity has it when heated? What is arsenic when pure? Are the varieties of iron very numerous?

LESSON XXXV.

POTASSIUM, BISMUTH, ARSENIC, COBALT, AND MANGANESE.

A FEW of the metals not described in the preceding lessons are of some value, but are not sufficiently important to be particularly described in this small work. A very brief description of a few should, however, be given.

Potassium is a metal obtained from potash. It has a great affinity for oxygen, and cannot be easily procured pure.

Bismuth is a white metal, very brittle, and used in the formation of metallic types. It is also one of the ingredients used by tinsmiths as solder. An alloy made by uniting eight parts of bismuth, five of lead, and two of tin, will melt when held in boiling water.

Arsenic has a metallic lustre and tin-white color. It is employed principally in giving a peculiar tint to glass, and in preparation of the poison known as arsenic. It is violent in its effect, — a very small quantity being sufficient to destroy life.

Cobalt has a metallic lustre, a steel-gray color, inclining to copper-red, when in the form of sulphuret. Less than half its weight is metal, and more than one-third sulphur.

Cobalt bloom resembles red antimony, and is sometimes mistaken for red copper ore. It is valuable in the manufacture of smalt, or blue glass.

Nickel has a strong metallic lustre, and tin-white color. It is found combined with copper, arsenic, meteoric iron, etc. The specific gravity is about eight. It melts or fuses less easily than iron.

Manganese is a hard, brittle metal, of grayish-white color, and very hard to melt. It exists in the form of oxides or silicates. Manganese ore is usually dark, nearly black, with a metallic lustre. It is employed in coloring glass, and in preparing chlorine gas, and also to procure chrome from the chromate of iron. Oxygen gas is often obtained from it, by heating powdered manganese in a retort. The black oxide of manganese is very common. It is often found in globular masses, in a position similar to bog iron ore, and not unfrequently combined with it.

Molybdena is a brittle metal, of white color. It occurs in the form of a sulphuret. Specific gravity about eight and a half. When found in the state of ore, it resembles plumbago, but may be easily distinguished from it by its scaly or lamellar structure.

Titanium is a red metal, somewhat resembling copper. It is very hard, and will scratch quartz. Specific gravity five and a half. The mineral known as sphene is an oxide of titanium, and is very beautiful.

Chromium is a brittle metal, of grayish-white color, very difficult to melt. Specific gravity is about six. It exists as an oxide, combined with both lead and iron. In its purely metallic state it has never been obtained but in small quantities. In its combinations, it is of much importance in the arts, being the basis of many of the paints employed in painting crockery ware, and also several paints employed on wood. Chrome yellow is prepared from chromic acid and lead.

Aluminum is the metallic base of alumina or clay. It has never been obtained in any considerable quantities. It is a beautiful gray metal, and may be procured in sufficient quantity to be employed in the arts.

Alumina enters largely into the composition of several of the precious stones, etc., as will be seen in Part II. It is very much more important in these relations than in any other.

Glucinium, Zirconium, and **Barium** are metals of importance chiefly as they aid in forming some of the precious stones.

Glucinium appears in the form of a gray powder, which acquires the metallic lustre by burnishing, and is an ingredient in emerald and beryl.

Zirconium exists in the form of a black powder, and is a principal ingredient in hyacinth.

Barium has a dark-gray color, with a lustre inferior to cast iron.

QUESTIONS ON LESSON XXXV.

Are the metals mentioned in this lesson of much value? Describe potassium. Define bismuth. Its uses? What alloy will melt when held in boiling water? What lustre and color has arsenic? For what employed? Is it a violent poison? Describe cobalt. What principal ingredient? What does cobalt bloom resemble? Its use? Color and lustre of nickel? How does it occur? Its specific gravity? Does nickel melt easily? Describe manganese. In what form does it exist? Its color and lustre? Its uses? How is oxygen gas obtained from it? What form of manganese is common? How is it found? Describe molybdena. Its specific gravity? What does it resemble when in the form of ore? How may it be distinguished from plumbago? Describe titanium. Its hardness? Specific gravity? With what metals is it combined as an oxide? Is it abundant in its pure state? Of what value in its combinations? How is chrome yellow manufactured? What is aluminum? Its color? Does it occur so frequently as to be used in the arts? In what is alumina a principal ingredient? In what form does glucinium appear? In what is it an ingredient? Describe zirconium. Color and lustre of barium?

PART SECOND.

PART SECOND.

SECTION I.

The preceding descriptions of the nine simple minerals which constitute the Alphabet of Geology, and their combinations in the formation of rocks, also the combustible minerals and the more important metals, leave extensive classes of minerals undescribed.

A knowledge of some of these is important to every one, and especially so to those engaged in agriculture. While the writer will aim to adapt a description of these, as far as possible, to the capacity of the young, the wants of those of maturer age, who have not the opportunity to study scientific and more extended treatises, will be consulted. Questions will not be added.

Some account of a class of substances called **Gases**, another **Acids**, and another called **Alkalies**, will be necessary. The relation of gases, acids, and alkalies to mineralogy, geology, and agriculture are many and important.

Oxygen is a name derived from two Greek words, signifying to make acid. It is a colorless, transparent gas, and is an element of both air and water. It forms a fifth part of the air, and about eight-ninths of water, and is, consequently, the most abundant substance known in nature. It enters into combination with earths, alkalies, and metals; it supports combustion, and is so important to animal life that no animal can live but a few seconds without a supply of it.

By far the greater part of the crust (solid part) of the earth is composed of substances which are combined with oxygen, and are called **Oxides.**

Iron rust is an oxide of iron; white lead is an oxide of lead. Oxygen gas is a little heavier than atmospheric air.

Hydrogen is a colorless gas, and derives its name from two Greek words, which mean to form water. It has a very strong affinity for many bodies, and is one of the elements of water, of which it forms one-ninth part. It is a combustible body, and burns with a large amount of flame. Being lighter than any other known gas, only one-sixteenth the weight of air, it is employed to fill balloons. It forms a great number of combinations with metals, earths, alkalies, etc.

Nitrogen is a colorless, tasteless, and inodorous gas, which constitutes about four-fifths of the atmosphere. It will not support combustion. No animal could live in the air from which the oxygen was removed and only nitrogen remained. But it is not poisonous of itself. Like the preceding gases, it combines with many other bodies, and forms with other gases several important compounds.

Chlorine gas is of a yellowish-green color, and has an astringent taste and disagreeable odor. It may be condensed to a liquid by great pressure. Its combination with other bodies forms important compounds. It has a strong affinity for several noxious substances, and is one of the greatest purifiers known to chemists.

Besides the gases above described are three other elements which enter into composition with several substances.

Iodine is a soft, pliable, opaque body, of bluish-black color and metallic lustre. It is changed to vapor by a degree of heat much less than boiling water. It has an extensive range of affinities. It unites with iron and other metals, and also with alkalies. It exists in combination with sea-weeds, sponges, and oyster-shells.

Bromine is a substance found in sea-water and sea-plants. At a common temperature it is a reddish-brown liquid, of a disagreeable odor, and caustic taste. Like iodine, it becomes a vapor at a temperature a little above blood heat. It unites with great energy with combustible bodies, and is a violent poison.

Fluerine is a substance not yet obtained in its pure and simple state. It appears to be a gaseous body. It exists abundantly in the mineral called fluate of lime, or fluor spar.

SECTION II.

—SEVERAL **Acids** are very intimately related to Mineralogy and Geology.

Nitric Acid, the result of a certain combination of nitrogen and oxygen, is a white liquid, with a nauseous odor. It unites with great energy with most metals, such as iron, tin, copper, etc., and is decomposed by them. When thus combined the substances formed are called **Nitrates.**

Muriatic Acid is a gas in its pure state, but is found, generally, in combination with other substances. The composition of it is one equivalent of hydrogen and one of chlorine. It aids to form salt, one of the most important substances.

Sulphuric Acid, often called oil of vitriol, is formed by a combination of sulphur, nitrogen, and water. It has a very strong affinity for many metals, and forms a very important class of substances called **Sulphates.**

Carbonic Acid is formed by the burning of carbon, and its union with the oxygen of the air. It exists very abundantly in nature, generally combined with lime, and forms carbonate of lime, or marble. It is colorless, inodorous, and elastic.

Phosphoric Acid, a combination of phosphorus and oxygen, is intensely sour, and combines with other bodies to form **Phosphates.**

Boracic Acid, a combination of boron and oxygen, exists in nature in small quantities. It combines with chlorine, fluorine, sulphur, soda, and other substances, and forms **Borates.**

Selenic Acid, composed of one equivalent of selenium and three of oxygen, is a colorless liquid. It dissolves gold, zinc, iron, and copper; unites with bases, and forms salts, similar in composition and form to those of sulphuric acid.

Hydriodic Acid is a colorless, transparent gas, very sour to the taste. This acid is employed in connection with some of the metals to form paints.

Hydrofluoric Acid is found essentially combined in fluor spar, and is obtained from it.

Titanic Acid is the peroxide of titanium, and constitutes nearly seventy-five per cent. of greenovite, and enters into the composition of sphene and other minerals.

Arsenious Acid is composed of two equivalents of arsenic and three of oxygen. It exists in the form of a dull-white powder, nearly tasteless, but is a violent poison.

Mellitic Acid is composed of four equivalents of carbon, four of oxygen, and one of hydrogen. It enters into the composition of several minerals.

Chromic Acid is produced by heating chromium with nitre. It is of a red color, and gives color to the ruby.

Columbic Acid is formed by columbium and oxygen, and enters into the composition of columbite, etc.

Tungstic Acid is composed of one equivalent of the metal tungsten and three equivalents of oxygen. It is found in several minerals.

Silicic Acid is light, white powder, which feels rough when rubbed between the fingers. It is inodorous and insipid. Rock crystal, flint, etc., are nearly pure silicic acid.

ALKALIES.

The more important alkalies, ammonia, potash, soda, lime, and magnesia, have a very intimate relation to minerals.

Potash is a protoxide of potassa, and is found in all plants, and many minerals.

Soda is a protoxide of sodium, and lime a protoxide of calcium. **Magnesia** is a protoxide of magnesium.

Most of these are very important to a good soil. The most useful grains and gases cannot be perfected without lime and potash. Most alkalies, except magnesia, have an acrid, burning taste, and a strong affinity for animal oils. The proportion in which they are present, in some of the important vegetables cultivated, will be seen in the table of analyses in Part III.

Ammonia is found united with carbonic, muriatic, and sulphuric acid. Sulphate of ammonia has a sharp, bitter taste, and is usually found near volcanoes, in the form of stalactites. It is composed of about fourteen per cent. of ammonia, fifty-four of sulphuric acid, and thirty-one of water.

Muriate of Ammonia, known under the common name of **Sal Ammonia,** has a sharp, nauseous taste, and gives an odor of ammonia. It is more usually found near volcanoes, but sometimes in coal mines which have been set on fire. It is manufactured largely in Egypt, from the excrements of animals which feed on plants impregnated with muriate of soda. When pure, it is composed of twenty-five per cent. of ammonia, about forty-three per cent. of muriatic acid, and thirty-two of water.

SECTION III.

Nitric Acid combines with potash to form the chemical salt called **nitre of Saltpetre.** This substance is found in nature, but, like sal ammonia, is mostly manufactured. It is composed of about forty-six and a half per cent. of potash, and fifty-three and a half per cent. of nitric acid. It forms crystals which are six-sided prisms. It is often found as an incrusting on the inside of caves in calcareous regions. In Kentucky a variety of sandstone, lying above limestone, contains so much saltpetre that a bushel of the stone will produce from ten to twenty pounds. Native nitre abounds in many places.

The important uses of this substance are medicinal, and in the manufacture of nitric acid and gunpowder.

Gunpowder is composed of seventy-eight parts of saltpetre, twelve of powdered charcoal, and ten of sulphur.

Both sulphuric and muriatic acids unite with soda, and form different substances of great importance.

Glauber Salt, so well known in medicine, is a sulphate of soda. It is an interesting fact, that while either of these substances alone is very acrid, when combined to form glauber salt, large doses of it may be taken into the stomach without injury.

Sulphate of Soda is composed of about nineteen per cent. of soda, twenty-five of sulphuric acid, and fifty-six of water.

Muriatic acid and soda form common salt, one of the most important articles known. This substance is very abundant in nature, being found in the water of all oceans. It also occurs in many springs and wells of water, and exists largely nearly pure in the earth in the form of rock, and is known as rock salt.

Rock Salt is usually found in crystals in the form of cubes. Sometimes masses are found tabular and prismatic. The purest varieties are nearly transparent. Its specific gravity is a little more than two.

Some mines in Poland have been wrought for more than six hundred years. One near Cracow is nearly one thousand feet deep, in which is a city of miners, who have places of worship, cut out in solid salt, with all the usual seats, etc.

Much salt is manufactured by evaporating or boiling salt water obtained from springs, wells, and also from the ocean.

Both men and most domestic animals require salt in order to health, and its importance in preventing putrefaction, and preserving meat, butter, etc., is well known.

The benevolence of our Creator, in furnishing abundant supplies of so important an article, must be readily perceived by every one. It is of very great value in agriculture and gardening, and should be, in small quantities, applied every year about the roots of every apple, pear, and plum tree growing more than twenty miles from the ocean.

SECTION IV.

Carbonic Acid, united with soda, forms the article usually called soda in commerce.

Carbonate of Soda has a warm, alkaline taste, somewhat caustic. It is composed of about twenty per cent. of soda, fourteen of carbonic acid, and sixty-five of water. The bi-carbonate of soda has, sometimes, thirty-seven per cent. of soda, and thirty-eight of carbonic acid.

This substance is extensively employed with silex in the manufacture of glass, also in making hard soap, and more or less in the culinary operations of every family.

Boracic Acid and **Soda** unite in forming the borate of soda. **Borax,** the common name of this substance, is, in its native state, impure, and bears the name of **Tincal.** When brought from India, it is in the form of prismatic crystals. It is purified before it is fit for use in the arts. Its most important use is as a flux in the soldering of metals.

Both sulphuric and carbonic acids are found combined with an oxide of a metallic substance called **Barytum.**

Barytes is characterized by its great weight, being nearly twice as heavy as marble, or other non-metallic minerals. Its specific gravity is from four and a quarter to more than four and a half. Sulphate of barytes is composed of sixty-eight per cent. of barytes, and thirty-two per cent. of sulphuric acid. It occurs both in the form of crystals and amorphous. The common name, heavy spar, is most appropriately given to it. It is harder than carbonate of lime, and will scratch it. Its color is usually a dull white, but it has other shades when united with small portions of iron, or other substances.

Various names are applied to designate different forms in which it occurs, as **Curved, Crested, Columnar, Radiated, Fibrous, Fetid,** etc. The uses of it are not very important. It is employed as a flux in metallurgy, and as a test in some chemical examinations. It has been employed as a base in water colors.

Carbonate of Barytes has about the same specific gravity as the sulphate. It is composed of seventy-eight per cent. of barytes, and twenty-two of carbonic acid. It is a rare mineral, and has been found chiefly in the lead mines of England. It is poisonous to some animals. It is found in this country in only a few places.

Both sulphuric and carbonic acid unite with a base called **Strontium,** which is an oxide. When pure it is white, resembling baryta.

Carbonate of Strontium is heavy, the specific gravity being from three and a quarter to three and five-sixths. It is harder than carbonate of barytes, and will scratch that mineral. It is composed of about seventy per cent. of strontium, and thirty of carbonic acid. Its form is generally fibrous, sometimes in fascicular groups.

Sulphate of Strontium is both massive and crystallized. Its specific gravity is from three and a half to four. It consists of strontium fifty-four per cent. and sulphuric acid about forty-six. It has different forms, which are specified by different names, **Foliated**, **Fibrous**, etc. Neither carbonate nor sulphate of strontium have been employed for any very important purposes in the arts.

SECTION V.

Fluoric Acid combines with lime, and forms fluate of lime. Its specific gravity is greater than carbonate of lime, being from three to three and three quarters. It is composed of about sixty-eight per cent. of lime, and thirty-two of fluoric acid.

The common name is **Fluor Spar**. It presents a variety of rich and beautiful colors, and very perfect crystals. The most common colors are green, violet, blue, yellow or red, though sometimes brown or black.

The colors are often so combined in the same specimen as, when polished, to be of rare beauty. It is wrought into vases and other articles, that are highly valued for ornamental purposes.

Fluoric Acid has a stronger affinity for silex than for lime.

Fluor Spar is employed for etching glass, the acid readily combining with the silex of the glass. The glass is coated with wax, and then the wax removed by the point of a needle or other instrument; and the solution, applied to the glass, wherever the wax has been removed, in a few minutes produces the etching desired.

It is found most abundantly in England, and the specimens are more beautiful than those generally found in this country.

Sulphuric, Boracic, and **Carbonic Acids** are found combined with **Magnesia.**

Sulphate of Magnesia, Epsom Salt, has a salt and bitter taste. It is found in native efflorescences on magnesian rocks which contain sulphuret of iron, in capillary fibres, or acicular crystals. It is often found on the walls of caverns.

It is composed of eighteen per cent. of magnesia, thirty-eight per cent. of sulphuric acid, and forty-four per cent. of water. It is found largely combined with, and is frequently manufactured from, some mineral waters. The common use of it in medicine, as a safe purgative, is well known.

Carbonate of Magnesia is usually granular, and may generally be known by adhering to the tongue. It is composed of forty-eight per cent. of magnesia and fifty-two of carbonic acid, and is very light. The magnesia of commerce, and sometimes used in medicine, is the only variety of much importance.

Borate of Magnesia is a rare mineral, composed of from sixteen to thirty-eight per cent. of magnesia, and from sixty-three to eighty-three per cent. of boracic acid. Sulphuric acid, combined with alumina and potash, forms alum, — an important and common mineral, used as a mordant in coloring.

Carbonic and sulphuric acid combine with lime, to form two of the most important rocks, described in the first part of this work, — carbonate and sulphate of lime. (See fourth and fifth letters of geological alphabet.)

SECTION VI.

SEVERAL minerals — the names of which frequently occur in books and periodicals, and some of which are interesting as cabinet specimens, and of great importance in the arts — have not been mentioned or described in the preceding lessons. Some of these should be described. They are found, on analysis, to be composed of several elements. They are generally crystalline in their structure, and often very beautiful. Some are mentioned in the Bible.

Sapphire is a beautiful mineral, composed principally of alumina, with minute portions of iron and silex. It has long been regarded as one of the precious stones. Its hardness is greater than that of any mineral except the diamond.

Sapphire is mentioned as one of the foundation stones of the city described Rev. xxi. as a type of heaven. Its specific gravity is greater than most of the precious stones, varying from three and three quarters to four and a quarter. Its most common colors are blue, red, yellow, and gray, and these mingled in beautiful proportions. When not crystallized, it is capable of being cut by lapidaries, and receiving a brilliant polish. Several varieties, owing principally to different shades of color, are specified, as *perfect*, *violet*, *blue*, *yellow*, etc.

Corundum varies from the preceding by a greater amount of silex and iron. It contains ninety-one per cent. of alumina, five of silex, and one to two of iron. A variety of this is known by the name **Adamantine Spar.**

Emery is a compact variety of corundum. Its great hardness makes it of much value in polishing all other hard bodies. Its specific gravity is about four. The emery of commerce is prepared by grinding it in a steel mill, and then washing. The emery bags used to polish needles contain a very fine powder of emery.

Spinelle is a mineral composed of alumina, magnesia, and chromic acid. It is sufficiently hard to scratch glass, but not so hard as sapphire.

— **Ruby**. This is the most common variety of spinelle. It crystallizes in beautiful octahedrons. The colors of the ruby are some shade of red, carmine, rose, violet, or cherry. Its specific gravity is from three and a half to three and three quarters. When analyzed it is found to contain eighty per cent. of alumina, eight or nine of magnesia, and six of chromic acid.

The ruby is highly esteemed in jewelry, though not so highly valued as red sapphire.

Ceylonite is a variety of spinelle. It is principally alumina and magnesia, but has also sixteen per cent. of iron. Its specific gravity is about three and a quarter. It is principally found in Ceylon, from which it is named.

Fibrolite is composed of fifty-eight per cent. of alumina, about thirty-eight of silex, and about one of iron. The form is that of a bundle of minute fibres, crossing each other. It is harder than quartz. The color brownish-white, with various shades.

Kyanite is a beautiful mineral, usually sky-blue, with a pearly lustre, crystallized in compressed six-sided prisms, many of them several inches in length. Its specific gravity is from three and a half to three and three quarters. The composition is alumina fifty-five per cent., silex thirty-eight, iron three, and a small amount of lime and water.

Rhœtizite is a variety of kyanite, but of a reddish-white or bluish-gray color. Its structure is fibrous, with a glistening lustre.

SECTION VII.

Staurotide is crystallized in four-sided prisms, but these often cross and interlace with each other. It is composed of about forty-seven per cent. of alumina, thirty-one of silex, fifteen of iron, and three of lime. Its color is reddish-brown, and sometimes nearly black, frequently with strong lustre. It forms pretty cabinet specimens, and is quite common, especially near mines of iron.

Pinite is a mineral somewhat resembling the preceding, having a greater per cent. of alumina, but no lime. It is found crystallized in the form of six-sided prisms.

Andalusite, frequently called macle, is a very hard mineral, readily scratching quartz. It occurs both massive and crystallized in the form of four-sided prisms, and these so united as to form a cross. By analysis it yields alumina fifty-two per cent., silex thirty-eight, potash eight, and iron two, and sometimes a trace of lime and magnesia. It has a vitreous lustre, white streak and colors flesh-red and pearly gray.

Blue Spar contains usually seventy per cent. of alumina, fourteen of silex, fourteen of magnesia, three of lime, and a trace of potash, iron, and water. It is sometimes called **Lazulite.** It occurs in masses, grains, and sometimes acicular crystals. The color is sky-blue, or bluish-white.

Chrysoberyl ranks next to the sapphire in hardness. It contains about seventy-two per cent. of alumina, eighteen of silex, six of lime, and one to two of iron. The form of its crystal is a four-sided prism, or a six-sided prism. Its color is greenish-white, and sometimes brownish-white. It is often employed in jewelry for necklaces, ring-stones, etc., and is highly valued.

Topaz is a very beautiful crystalline mineral. The crystals have a great variety of prismatic forms. Its more common color is yellow, but exhibits shades of pale green, greenish-white, and sometimes bluish-white. It is composed of about fifty-eight per cent. of alumina, thirty-four of silex, and seven or eight of fluoric acid.

The harder and purer varieties of topaz are much employed in jewelry, and are highly valued. It has long been known as one of the precious stones, and is mentioned in the Bible.

Pycnite is composed of similar substances, but the proportions differ.

The two following minerals, **Zircon** and **Hyacinth,** are composed largely of zirconium.

Zircon is a hard, heavy mineral, usually crystallized in the form of a four-sided prism. Its more common colors are gray or green. It is composed of zirconia about sixty-six per cent., silex thirty-one, and iron two. It has been sometimes sold as diamond. It is very valuable in jewelry.

Hyacinth is a variety of zircon, and is highly valued in jewelry. Neither is very common.

Several minerals are composed of silex, alumina, and an alkali, with more or less iron, but in which the proportion of silex is greater than alumina. A part of these have been described under the second and third letters of the geological alphabet. Some others should be described in this place.

Schorl is a very common mineral. The crystals are usually long prisms, commonly black or dark color, very brittle, and sufficiently hard to scratch glass. The lustre is usually splendid. The composition varies in different specimens, though not materially: silex thirty-seven per cent.; alumina about thirty-five, potash six, and iron twenty-one.

The name **Tourmaline** is usually given to those varieties which are green, red, yellow, or brown, some of which are exceedingly beautiful as cabinet specimens.

Indicolite is a deep-blue variety, resembling indigo, from which it derives its name. Instead of potash it has a few per cent. of lithia, of manganese, and boracic acid. It has about an equal portion of silex and alumina.

Rubellite resembles schorl in the form of its crystals, but its color is usually some shade of red,—rose, peach-blow, lilac, and even crimson. It has silex about forty-two, alumina forty, soda ten, and iron seven per cent. One single specimen, consisting of several crystals, now in the British National Museum, has been valued as high as two thousand dollars. Rubellite is highly prized by lapidaries for the formation of jewels.

Emerald, one of the richest gems, is always crystallized in six-sided prisms. The prevailing color is green, very lively and beautiful. It is composed of silex sixty-four per cent., alumina sixteen, chrome three, and glucina thirteen. The latter metal is found only in emerald, beryl, and euclase. The emerald, when perfect, is employed in the most expensive kinds of jewelry.

Beryl is a beautiful crystal, generally green, but sometimes honey-yellow. The color is less rich than in the emerald, and is probably derived from iron instead of chrome. It contains silex sixty-eight per cent., alumina fifteen, glucina fourteen, lime two, and oxide of iron one. The crystals are six-sided, and have been found a foot or more in diameter. One of the largest is in the cabinet of Dartmouth College. Fine cabinet specimens may be obtained at Ackworth and Groton, New Hampshire, and many other places in this country.

Euclase is a rare and very brittle mineral, composed of silex about forty-three per cent., alumina thirty-one, glucina twenty-two, oxide of iron two, and nearly one of tin. The color varies from deep sky-blue to greenish-white.

Iolite occurs in six-sided prisms, of violet-blue color. It contains about forty-three per cent. of silex, thirty-five of alumina, fifteen of iron, six of magnesia, and one to two of lime and manganese. Though often found in Europe, and also in a few localities in this country, it is a rare mineral.

Basalt is generally regarded as a volcanic rock, the ingredients of which are principally silex, alumina, iron, and lime, with a few per cent. of soda and magnesia. Some, however, affirm that there is in some specimens no appearance of its having been melted. It is frequently columnar. Geologists widely disagree with regard to its origin.

Scapolite usually occurs in four or eight-sided prisms, and frequently terminated by a four-sided pyramid, the color generally some shade of grayish-white, but sometimes inclining to red or blue. It is composed of about forty-five per cent. of silex, thirty-three of alumina, thirteen of lime, with one or two of soda and potash.

Garnet is both a common and beautiful mineral. Its crystals are dodecahedrons or twelve-sided in form. The sides are sometimes increased to twenty-four, and even thirty-six, sixty, and eighty-four. It sometimes occurs massive. Its analysis yields about thirty-six per cent. of silex, twenty-seven of alumina, and thirty-six of oxide of iron. The color is usually some shade of red, with a strong lustre. The crystals are generally smaller than peas, but sometimes half an inch or more in diameter. It abounds in many mica slate rocks. A beautiful variety of precious garnet is frequently met with in hornblende slates.

Pyrope, Topazolite, Succinite, Melanite, Pyrenaite, and **Colophonite** are frequent varieties.

Cinnamon Stone is a beautiful massive variety.

Colophonite is one of the most beautiful of these varieties, comprising a mass of small crystals which reflect all the colors of the rainbow. Precious garnet and pyrope are often employed in jewelry.

Epidote is both crystallized, lamellar, and massive. The crystals are usually six-sided prisms; the color from a light to a dark green. The analysis of epidote yields thirty-seven per cent. of silex, twenty-seven of alumina, fourteen of lime, and seventeen of oxide of iron.

Zoisite is a variety of epidote, composed of striated and rhomboidal prisms, frequently compressed and rounded.

Arenaceous epidote occurs in grains of various forms, of a yellowish-green color and vitreous lustre.

Manganesian epidote occurs in acicular crystals and prismatic crystals, with a lustre more or less pearly.

Idocrase usually occurs in short four-sided prismatic crystals, with highly polished surfaces. The crystals are sufficiently hard to scratch glass. The composition is silex about thirty-six per cent., lime thirty-three, alumina twenty-two, oxide of iron five to six. Its colors vary from brownish-green to yellowish-brown, and sometimes have a shade of reddish yellow.

Egeran is a variety of idocrase, usually having a reddish-brown color. It is sometimes employed as an ornamental stone.

Prehnite is generally crystallized in right rhombic crystals, imperfectly foliated. Its color is almost always a light green, but sometimes has a tinge of yellow. It is composed of about forty-four per cent. of silex, thirty of alumina, eighteen of lime, seven of oxide of iron, and one to two of water. But the analysis varies considerably in specimens taken from different places.

Kouphòlite is a variety of prehnite, more shining and pearly, usually found in minute rhomboidal plates.

Stilbite crystallizes in four-sided prisms, often acicular, and sometimes grouped in bundles fan-shaped, having a beautiful pearly lustre. Foliated masses frequently occur. By analysis it is found to contain about fifty-two per cent. of silex, seventeen of alumina, nine of lime, and eighteen of water.

Zeolite resembles stilbite in several of its features, but differs in analysis. Its color is nearly white. It occurs usually in fibrous masses, or groups of acicular crystals, and these diverge or radiate from a given point. The lustre is glistening and pearly. Zeolite is found by analysis to contain about forty-nine per cent. of silex, twenty-nine of alumina, nine or ten of lime, and ten of water. **Natrolite,** mealy zeolite, and **Crocalite** are varieties of zeolite. This and the prehnite furnish beautiful cabinet specimens, but are not often employed for any other important purpose.

Laumonite is a mineral named from the person who discovered it. It is found in laminated masses, or groups of prismatic crystals. The color is usually grayish or reddish white. It is transparent or translucent, and contains about fifty per cent. of silex, twenty-two of alumina, nine of lime, seventeen or eighteen of water, and two or three of carbonic acid.

Harmotome is a grayish-white mineral, though sometimes reddish, always found crystallized in rectangular four-sided prisms. These crystals are frequently grouped. It consists of about fifty per cent. of silex, eighteen of barytes, sixteen of alumina, and fifteen or sixteen of water.

Chrysolite occurs in four-sided prisms, is usually green, with shades of yellow or brown; and is both harder and heavier than phosphate of lime, which it somewhat resembles.

Olivene is a variety of chrysolite. It contains silex fifty per cent., magnesia about thirty, and oxide of iron twelve. It is often found near volcanoes.

Augite occurs usually in six-sided prisms, but sometimes in foliated masses, or amorphous. The color is usually brown, with a shining lustre. It is harder than hornblende or olivene. It is composed, usually, of fifty-two per cent. of silex, fourteen of lime, thirteen of magnesia, six of alumina, twelve or thirteen of oxide of iron, and with a trace of water and manganese.

Sahlite, Fassaite, and **Coccolite** are varieties of augite, the latter often in octahedral crystals slightly adhering together. The preceding form pretty cabi net specimens, but are not of much use in the arts.

Many other minerals are described in complete treatises on mineralogy, but have been omitted because a description of them would extend this work beyond the limits intended, and because they are less important. A concise definition of them will generally be found in Webster's Dictionary.

PART THIRD.

PART THIRD.

SOILS, THEIR FORMATION, ETC.

Soils are composed of materials which form the rocks and minerals previously described; varying very much in constituents, according to the character of the rocks lying near, or those from which *drift* soil has been removed.

Few things are more important, in an agricultural community, than some practical information with regard to the character of soil. Ability to judge of the adaptation of different soils to different articles of produce might prevent much useless effort and needless expense. This knowledge, by some, has been gained by experience. But in many cases this has been costly knowledge.

A fact or two may illustrate the *expense* of knowledge sometimes gained by experience.

Judge C., a very intelligent gentleman, when nearly seventy years of age, purchased a residence in the pleasant village of P. During the first season after, he noticed a plant growing with great luxuriance in one part of his garden, and endeavored to eradicate the nuisance, by pulling it up by the roots. He persevered in his efforts till he made a pile of it "large as a hay-cock." Here he was arrested by a painful disease, developed on his face, hands, arms, etc., causing great alarm, as well as intense suffering. A friend who visited him pronounced it poison, resulting, doubtless, from ivy or dogwood. But the learned judge assured him it could not be, for he had not gone beyond the limits of his garden for several weeks. An examination of a few minutes revealed the fact that the plant he had been endeavoring to eradicate from his garden was no other than *poison ivy;* of the appearance and nature of which he had remained entirely ignorant to old age. Ignorance of what might have been learned in a few minutes proved very costly to him.

Mr. H., residing in S., a few years ago erected a costly house of brick. In digging the cellar, he had removed many tons of beautiful stone, which he determined to employ for the backs and jambs of fireplaces, remarking that it was more beautiful than brick. He had freighted lime for mortar, etc., nearly a hundred miles, at a heavy expense. During the first winter after occupying his new house he found the stone crumbling and his chimneys in danger of falling, and, to his surprise, then learned that the beautiful stone employed was very pure carbonate of lime!

Thousands of striking facts are brought to light, in the history of agriculture, perhaps quite as expensive to many, resulting from ignorance of things which might have been learned as easily as the knowledge which would have prevented the suffering and loss to Judge C. and Mr. H.

It is important to all, especially so to the young, to acquire a knowledge of a few general principles with reference to the *formation of soils*, their adaptation to particular grains or grasses, and the way in which the elements that are exhausted from the soil by cultivation may be most cheaply supplied.

Some facts in the history of what is *now dry land* are very intimately connected with the present character of soil. A very large proportion of the land in the United States, and many other countries, was once covered by the waters of the ocean; and in some places so recently that undecomposed sea-shells remain in the clays and soil. During that period there were either strong currents passing, generally from the north or north-west, towards the south or south-east, with sufficient force to move loam, sand, gravel, and even rocks, to a great distance.

Icebergs, like those now common in the Atlantic Ocean, were driven by the winds, bearing vast fragments of rock a great distance from the original strata from which they were taken. If a field of granite existed in a given place where icebergs were formed, fragments, etc., of that rock would be removed many miles, and be found in the soil, or lying on rocks of very different kind, in the direction in which the current or iceberg moved.

In order to know what constituents may be expected to exist in the soil of any particular place, the general character of the ledges or strata lying in a northerly direction should be known. If there is a large field of limestone in any given locality, and a field of granite lying southerly, fragments of the limestone will be found deposited on the granite, and much of the soil will contain a large per cent. of lime. If that limestone is silicious, and more than usually friable, in consequence of containing sulphuret of iron (like much of the limestone on the easterly side of Vermont and a part of Massachusetts), almost the entire soil, in the direction of the drift, will contain a large proportion of both silicate and carbonate of lime. Bog iron ore may be found in low places. Where the general slope of surface and direction of the streams harmonize with the direction of the ocean drift, it may be expected to extend farther and be more abundant than when this order is reversed.

The peculiar productiveness of the great Ox-bow and other Connecticut River intervals may be attributed, in part at least, to the drift from the limestone region of Canada and Vermont.

Very large tracts of land may be found in many parts of this country which were once the bottom of oceans, lakes, etc. These tracts will be found to consist of clays and alluvial soil, derived from the surrounding higher lands, modified to some extent by the rock in place, and by the action of streams that have flowed through such lands. Interval soil, bordering on a given stream, is not only modified by its degree of elevation, but by the character of the rocks in place, and of the drift over which the water of the river and its tributaries has passed; from which it was deposited. Upland soil often presents still greater diversities, owing to the character and depth of the drift, the qualities of the rock or subsoil over which it lies, the relation of its surface to the dip of strata, and the presence of different proportions of vegetable matter, metallic oxides, and earthy salts. Rocks decompose and form *new* soil with very different degrees of rapidity. Talcose slate, varieties of clay slate, and some other rocks, contain the striæ, or drift scratches, on the surface of ledges, made at the drift period by the passage of rocks or icebergs. That period must have occurred long ago, for we know these rocks have not decomposed much, for an immensely long period.

On other kinds of rock these drift scratches are *all obliterated*, and not only so, the entire surface, that was once ledge or rock, is now changed to arable soil. Both of these facts are illustrated in each of the New England and Middle States.

Talcose slate has been affected least, and silicious lime and clay slate, containing large portions of sulphuret of iron, have been affected the most, by decomposition.[1]

When soil is under cultivation, every crop of grass, grains, or roots, removed from it, takes away a portion of the elements necessary for their growth. If these elements are not in some way supplied, the soil rapidly deteriorates, and becomes poor or barren. By ascertaining the elements of the rocks and minerals previously described, some estimate may be made of the character of the soil where any particular variety is found abundant, unless the soil has been greatly modified by drift, and the agencies previously described.

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[1] "Pyrites, or the bi-sulphuret of iron, exerts the most powerful agency in the decomposition of rocks, and, perhaps, the most extensive, as this mineral is widely disseminated through nearly all classes of rocks. It is composed of sulphur and iron. The sulphur attracts oxygen from the air and from water, and forms the well-known substance sulphuric acid (oil of vitriol). The iron also combines with oxygen from the same source, and forms an oxide of iron. The acid and the oxide now unite, and produce a new compound, the *sulphate* of iron or copperas, a substance capable of being dissolved in water. Thus, the rock through which the pyrites is disseminated is crumbled down and changed in its properties. But the action does not stop here. The sulphate of iron being dissolved in water, which is constantly penetrating the mass, is brought into contact with feldspar, and both are decomposed; the sulphuric acid in the copperas abandons the iron, and unites with the potash and the lime in the feldspar, forming sulphate of potash and of lime, while the oxide of iron is deposited in the form of iron rust. When the pyrites exists in slate rocks, containing much alumina, magnesia, and lime, the sulphuric acid combines with these bases, by which nearly the whole rock is gradually converted into soil. Were this the only agent acting upon the rocks, the character of the

soil would be accurately known by examining the rock which underlies it; but this is rarely the case.

"The above processes will serve to illustrate the chemical and mechanical agencies which are constantly at work to crumble down the solid rocks, and bring them into a state fit for the support of the vegetable kingdom. These agents are constantly active. The great effect of stirring the soil is to facilitate the decomposition of the rocks, and of the vegetable bodies which are always present in the soil. But for this agency the soils in a few years would become exhausted of all their alkalies, the vegetable matter would not decay, and hence no food in the soil would be provided for the plants. Absolute barrenness must, therefore, succeed. For without alkalies, or alkaline earths and geine, no plants can grow.

"*Depth of Soil.* — The influence of the agents above described has not extended to an average depth of more than fifteen feet; although in some places the soil is actually more than one hundred feet in depth. This is but a small portion of the whole mass of the earth, whose mean diameter is seven thousand nine hundred and eleven miles; hence, the soil would be less in proportion to the whole earth than the slightest tarnish of rust on an iron globe one hundred feet in diameter compared with its mass. But a small part of this constitutes what is properly denominated the soil." — *Gray's Elements of Scientific and Practical Agriculture.*

By an examination of the following statement, it may be readily seen what elements of the soil and what proportion of them are removed by the growth of the common articles of produce mentioned in the first column, and what materials ought to be largely supplied to the soil in order to cause it to continue productive.

In one thousand pounds of wheat, rye, oats, barley, etc., are found the number of pounds and decimals of a pound of the various substances mentioned, as stated by Sprengel, an able and reliable chemist. It will be seen that potatoes and potato-stalks use up many elements of the soil very rapidly. The table should be very carefully studied.

	Potassa.	Soda.	Lime.	Magnesia.	Alumina.	Oxide of Iron.	Oxide of Maganese.	Silica.	Sulphuric Acid.	Phosphoric Acid.	Chlorine.
Wheat,	2.25	2.40	0.96	0.90	0.26			4.00	0.50	0.40	0.10
Barley,	2.78	2.90	1.06	1.80	0.25			11.82	0.59	2.10	0.10
Rye,	.05	32.00	1.22	0.44	0.24	0.42	0.34	1.64	0.23	0.46	0.09
Oats,	1.50	1.32	0.86	0.67	0.14	0.40		19.76	0.35	0.70	0.10
Beans,	4.15	8.16	1.65	1.58	0.34			1.26	0.89	2.92	0.41
Peas,	8.10	7.39	0.58	1.36	0.20	0.10		4.10	0.53	1.90	0.38
Potatoes,	40.28	23.34	3.31	3 24	0.50	0.32		0.84	5.40	4.01	1.60
Wheat Straw,	0.20	0.29	2.40	0.32	0.90			28.70	0.37	1.70	0.30
Barley Straw,	1.80	0.48	5.54	0.76	1.46	0.14	0.20	38.56	1.18	1.60	0.70
Oat Straw,	8.70	0.02	0.52	0.23	0.06	0.02	0.02	45.88	0.79	0.12	0.05
Rye Straw,	0.32	0.11	1.78	0.12		0.25		22.97	1.70	0.51	0.17
Bean Stalks,	16.56	0.50	6.24	2.00	0.10	0.07	0.05	2.20	0.34	2.26	0.80
Pea Stalks,	2.35		27.30	3.42	0.60	0.20	0.07	9.36	3.37	2.40	0.04
Potato Stalks,	81 90	0.90	129.70	17.00	0.40	0.20		49.40	4.20	19.07	5.00
Rye Hay,	8.81	3.95	7.34	0.90	0.31			27.72	3.53	0.25	0 06
Red Clover Hay,	19.95	5.29	27.80	3.33	0.14			3.61	4.47	6.57	3.62
White Clover Hay,	31.05	5.79	23.48	3.05	0.90	0.63		14.73	3.53	5.05	2.11
Lucerne,	19.40	6.15	48.31	3.48	0.30	0.30		3.30	4.04	13.07	3.18

Granite, gneiss, syenite, hornblende, limestone, and clay slate decompose with considerable rapidity in some places, and in others so slowly as to affect the condition of the soil but slightly for a long period of time. As a general thing, the more recent the elevation of these varieties, the more rapid is the progress of decomposition. The granite in Eastern Vermont, and some portion of New Hampshire, is probably about the same age with the Green Mountains. It was certainly thrown up since the lime and clay and hornblende (called by Prof. Adams calcareo-mica slates) were formed, because we find fragments of all these imbedded in the granite, gneiss, etc., in many places.

Several rocks are composed largely of elements highly favorable and necessary to a productive soil.

Granite is composed, as already stated, of quartz, feldspar, and mica. Quartz, or silica, is important in every soil. Feldspar usually contains thirty-three per cent. of alumina, thirteen of soda, seven of potash, and one to two per cent. of oxide of iron, lime, and manganese. Mica contains about twelve per cent. of alumina; thirteen of magnesia, seven of potash, and oxide of iron from three to five.

Wherever granite rock has become decomposed, there are abundant materials for a good soil till these materials are exhausted by cultivation. Where lime has been supplied by drift, or otherwise, the soil will be greatly improved.

Hornblende slate contains, besides silica, some fifteen to eighteen per cent. of magnesia, ten to fifteen of lime, seven to twelve of alumina, seven to eighteen of protoxide of iron, with one to two per cent. of manganese and hydrofluoric acid.

When this slate is interstratified with clay and lime slates, the soil is of great strength and durability, and highly favorable for growing wheat, barley, and the best varieties of grass.

Where the calcareo-mica slate has an adequate supply of argillite in its formation, it forms a most productive and retentive soil. If there is a deficiency of clay, it is affected by drought, and is less productive.

The talcose slate rocks contain elements important to vegetation, but do not yield them readily by decomposition. Lime, magnesia, and potash must, on such soil, be largely supplied after a few years of cultivation, or it will greatly deteriorate. This is already the experience of many farmers in the region where this is the prevailing rock, except on the borders of streams, where the drift, or alluvial soil, is deep.

Wherever carbonate of lime is the prevailing rock, and decomposition is rapid, the soil will have great strength, and will be found highly favorable to wheat, grass, and fruit. The islands in Lake Champlain, many towns bordering on that and Lake Ontario, and, indeed, most of Northern and Western New York, furnish good illustrations of such soil.

Of the character of sphagnous, muck, or peat, every one ought to have some knowledge. Numerous and sometimes vast beds of this very important substance abound in New England, and will be regarded, when its real value is adequately known, as one of the most benevolent provisions of the Creator for the necessities of man. Dr. Emmons, one of the geological surveyors of the State of New York, remarks: "Perhaps it would be saying too much to assert that peat is more valuable than coal; but when we consider that, for creating heat, it is not inferior to bituminous coal; that it contains gaseous matter equal in illuminating power to oil or coal gas; that its production is equally cheap, and, in addition, that it is a valuable manure if properly prepared, — the intrinsic worth of peat (muck) cannot fall far short of the poorer kinds of coal."

This substance is highly important for several purposes, as intimated in the remark above, but

I regard its present value chiefly as a fertilizer. It contains the elements of barn manure, and, by the union with a few per cent. of house-ashes, quicklime, soda ash, etc., it is more valuable than that manure. It is highly useful to be applied to clayey soils to make them more porous, and equally valuable for lighter soils, for securing and retaining moisture for the use of the growing crop.

When dried, it is the most valuable substance for absorbing and retaining the liquid manure of the stable, and, when thus employed, needs no other preparation to make it one of the most cheap and important fertilizers. It is generally so well distributed, especially where limestone abounds, that most farmers, in such places, can avail themselves of it; and by converting the shell marl, or limestone, into caustic lime, and combining it with muck, entire farms may be made as productive as gardens, without any outlay for more expensive manures.

LOCALITIES OF MINERALS FOUND IN NEW ENGLAND, THE MIDDLE STATES, ETC.

It is not practicable to give, in this small volume, the localities of *all* the minerals found in the Northern and Middle States, much less in the whole country. But a notice of a few prominent ones may be of much service to many who cannot have access to more extended Catalogues.

Maine.

Albany. — Beryl, green, black, and red tourmalines, feldspar, rose quartz.

Blue Hill Bay. — Arsenical iron, molybdenite, galena, apatite, fluor spar, black tourmaline, black oxyd of manganese, red manganese, bog manganese, wolfram.

Brunswick. — Green mica, garnet, black tourmaline, molybdenite.

Deer Lake. — Serpentine, verd antique, asbestos, diallage.

Lubec Lead Mines. — Galena, copper pyrites, blende, pyromorphite.

Paris. — Green, red, black, and blue tourmaline, mica, lepidolite, feldspar, albite, quartz crystals, rose quartz, blende.

Parsonsfield. — Idocrase, yellow garnet, pargasite, adularia, seapolite, galena, blende, copper pyrites.

New Hampshire.

Acworth. — Beryl, mica, tourmaline, feldspar, albite, rose quartz, columbite.

Eaton. — Galena, blende, copper pyrites, limonite.

Franconia. — Hornblende, staurotide, epidote, zoisite, specular iron, magnetic iron, black and red manganesian garnets, mispickel (Danaite), copper pyrites, molybdenite.

Grafton.— Mica, albite, asparagus stone, triphyline, blue, green, and yellow beryls.

Lisbon. — Staurotide, black and red garnets, granular magetic iron ore, hornblende, epidote, zoisite, specular iron, gold.

Lyme. —Kyanite, black tourmaline, rutile, iron pyrites, copper pyrites, sulphuret of antimony.

Unity. —Copper and iron pyrites, chlorophyllite, green mica, magnetic iron, radiated actinolite, garnet, titaniferous iron ore, magnetic iron ore.

Warren. — Copper pyrites, blende, epidote, quartz, iron pyrites, tremolite, galena, rutile, talc, molybdenite.

VERMONT.

New Fane. — Glassy and asbestiform actinolite, steatite, green quartz, chalcedony, drusy quartz, garnet, chrome iron, rhomb spar.

Holland. — Many varieties of hornblende, scapolite.

Plymouth. — Spathic iron, gold.

Readsboro'. — Glassy actinolite, steatite.

Stafford. — Magnetic iron, copper pyrites, iron pyrites, crocus of Mars, colthar.

Windham. — Glassy actinolite, steatite.

MASSACHUSETTS.

Bolton. — Scapolite, petalite, sphene, pyroxene, Nuttallite, diopside, Boltonite, apatite, magnesite, rhomb spar, Allanite, yttrocerite, cerium ochre (on the scapolite), spinel.

Chesterfield. — Blue, green, and red tourmaline, Cleavelandite (albite), lithia mica, smoky quartz, pyrochlore (microlite), spodurmene, kyanite, apatite, rose beryl, garnet, quartz crystals, staurotide, tin ore, columbite, variegated copper ore, zoisite, uranite.

Deerfield. — Chabazite, Heulandite, stilbite, amethyst, carnelian, chalcedony, agates.

Goshen. — Lithia mica, albite, spodumene, blue and green tourmaline, beryl, zoisite, smoky quartz, columbite, tin ore, galena, phenakite.

Lancaster. — Kyanite (variegated fibrolite), chiastolite, apatite, staurotide, pinite, andalusite.

Pelham. — Asbestos, serpentine, quartz crystals, beryl, molybdenite, green hornstone.

Saugus. — Jasper, hornstone, amygdaloid.

South Royalston. — Beryl, common mica, feldspar, Ilmenite, Allanite.

Worcester. — Mispickel, idocrase, pyroxene, garnet, amianthus, Bucholzite, spathic iron, galena, anthracite.

RHODE ISLAND.

Cumberland. — Manganese spar, epidote, actinolite, garnet, titaniferous iron, magnetic iron, red hematite, copper pyrites.

Smithfield. — Dolomite, calc-spar, bitter spar, macrite, rephrite, tremolite, asbestos, quartz, magnetic iron in chlorite slate, talc.

CONNECTICUT.

Cheshire. — Heavy spar,(z) vitreous copper, cryst, variegated copper, green malachite, kaolin, natrolite, prehnite, chabazite, epidote.

Haddam. — Chrysoberyl, beryl, epidote, tourmaline, feldspar, anthophyllite, garnet, iolite, chlorophyllite, automolite, magnetic iron, adularia, apatite, columbite, white and yellow iron pyrites, molydbenite, Allanite, sulphuret of bismuth.

Middletown. — Mica, lepidolite with green and red tourmaline, albite, feldspar, columbite, prehnite, rutile, beryl, topaz, uranite, apatite.

Trumbull and Monroe. — Chlorophane, topaz, beryl, euclase, magnetic pyrites, iron pyrites, tungstate of lime, wolfram, pseudomorph of tungsten, rutile, native bismuth, tungstic acid, spathic iron, topaz, mispickel, argentiferous galena, blende, scapolite, tourmaline, garnet, albite, augite, graphic tellurium.

NEW YORK.

Essex County.

Crown Point. — Garnet, massive feldspar, epidote, epsom salt, apatite (eupyrchroite of Emmons), magnetic iron.

Jefferson County.

Antwerp. — Quartz crystals, serpentine, calc-spar, spinel, mica, spathic iron, specular iron, arragonite, cacoxene, terenite, tremolite, fluor, green malachite.

Lewis County.

Diana. — Scapolite, tabular spar, green coccolite, feldspar, apatite, sphene, mica, quartz crystals, drusy quartz, cryst, pyrites, magnetic pyrites, blue calc-spar, serpentine, Rensselaerite.

Niagara County.

Lockport. — Celestine, calc-spar, selenite, anhydrite, fluor, pearl spar, blende.

Orange County.

Amity. — Spinel, garnet, scapolite, hornblende, idocrase, epidote, clintonite, magnetic iron, tourmaline, Warwickite, apatite, chondrodite, ilmenite, talc, pyroxene, rutile, zircon, corundum, feldspar, sphene, calc-spar, serpentine, schiller spar.

St. Lawrence County.

Hammond. — Apatite, zircon, feldspar, heavy spar, pyrites.

Westchester County.

Sing Sing. — Pyroxene, tremolite, iron pyrites, copper pyrites, beryl, azurite, green malachite, white lead ore, pyromorphite, Anglesite, Vauquelinite, galena, native silver.

NEW JERSEY.

Bergen. — Calc-spar, datholite, Thomsonite, pectolite, analcime, epistilbite, apophyllite, prehnite, sphene, stilbite, natrolite, Heulandite, Laumonite, chabazite, pyrites, pseudomorphous steatite, imitative of apolphyllite.

Franklin and Hamburgh. — Spinel, garnet, manganese spar (Fowlerite), Troostite, Franklinite red zinc ore, dysluite, hornblende, tremolite, chondrodite, white scapolite, black tourmaline, epidote, pink calc-spar, mica, actinolite, augite, sahlite, coccolite, asbestos, Jeffersonite, calamine, graphite, fluor, beryl, galena, serpentine, honey-colored sphene, quartz, chalcedony, amethyst, zircon, molybdenite, vivianite.

Newton. — Spinel, blue and white corundum, mica, idocrase, hornblende, tourmaline, scapolite, rutile, pyrites, talc, calc-spar, heavy spar, pseudomorphous steatite.

PENNSYLVANIA.

Delaware County. — Corundum, andalusite, aventurine, feldspar, amethyst, green quartz, beryl, black tourmaline, apatite, garnet, Bucholzite.

Lancaster County. — Anthophyllite, cryst, pyrites, moss agate, chalcedony, rutile.

DELAWARE.

Wilmington. — Blue apatite, glassy feldspar, sahlite, sphene in pyroxene, kyanite.

MARYLAND.

Baltimore. — Haydenite, Heulandite, pyrites, carbonate of iron, mica, stilbite.

Cooptown. — Olive-colored tourmaline, diallage, talc of green, blue, and rose colors, ligniform asbestos, chromic iron, serpentine.

SUPPLEMENT.

THOUGH it was not intended, when the preceding pages were written, to embrace anything beyond the classification and description of the simple minerals, rocks, metals, combustible minerals, soils, etc., it is thought desirable to add a further description of the classification of rocks, with a few illustrations in palæontology.

Geologists formerly divided the rocks into four classes, primitive, transition, secondary, and tertiary. The lowest rock is granite, and above that gneiss and other primary rocks, then transition, etc., as illustrated in the accompanying diagram.

But it was found that this division was not adequate. There are large classes of metamorphic rocks, lavas, and other igneous rocks, which, in order to be represented, required important modifications. It is now known that nearly "all the rocks accessible to man have undergone entire and some of them repeated changes since they were first created."[1] The agents of metamorphism are still operating. A prominent agent is heat. It is now believed by every respectable geologist that the interior part of the earth, within a few hundred miles of the surface, is in a molten state, like the lava thrown out from volcanoes, or "burning mountains," — Vesuvius, Etna, and those at the Hawaiian Islands. Rocks are being formed now at the bottom of seas, lakes, etc., and also by lava from volcanoes.

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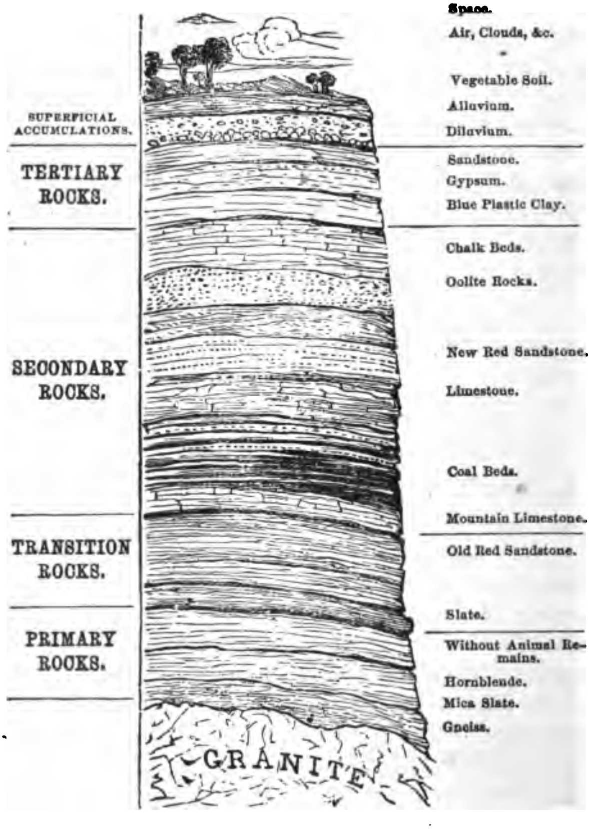
[1] Prof. Hitchcock.



THE ORDER OF THE STRATA WHICH FORM THE CRUST OF THE EARTH.

All the rocks above those marked as primary on the diagram have been formed since vegetables and animals were formed. The strata are of immense thickness, in which the remains of vegetables, trees, and animals are found. The fossiliferous rocks are divided into three classes, the palæozoic (transition on the diagram), the secondary, and tertiary, as marked on the diagram.

Prof. Hitchcock gives the names and arrangement of the rocks, divided into periods, as follows:—

I. FOSSILIFEROUS.

Coinozoic Period.

1. Alluvium, embracing drift.
2. Tertiary.

Mesozoic Period.

1. Cretaceous, with green sand.
2. Oölitic, or Jurassic, with Wealden and Lias.
3. Triassic, or New Red Sandstone.

Palæozoic Period.

1. Permian.
2. Carboniferous.
3. Devonian.
4. Upper Silurian.
5. Lower Silurian.
6. Cambrian.

II. UNFOSSILIFEROUS, OR AZOIC.

1. Clay Slate.
2. Quartz Rock.
3. Mica Schist.

4. Talcose Schist and Chlorite Schist.
5. Steatite, or Soapstone.
6. Serpentine.
7. Hornblende Schist.
8. Gneiss.
9. Crystalline Limestone.

UNSTRATIFIED, OR IGNEOUS ROCKS.

1. GRANITIC.

1. Granite.
2. Syenite.
3. Graphic Granite (Pegmatite).
4. Protogine.

2. TRAPPEAN.

1. Greenstone, or Diorite.
2. Tufa, or Greenstone Ash.
3. Hornblende Rock.
4. Hypersthene.
5. Felstone.
6. Feldspar Porphyry.
7. Quartziferous Porphyry.

3. VOLCANIC.

1. Basalt.
2. Dolerite.
3. Amygdaloid.
4. Peperino.

5. Trachyte.
6. Trachyte Porphyry.
7. Pumice.
8. Tuff, etc.

Some of the above formations are subdivided, by both European and American geologists; but it is not necessary to give them in this little volume. The position of all the rocks above granite may be learned from the diagram, except the trappean and volcanic rocks, which do not occur in regular or uniform strata.

The fossiliferous rocks are of intense interest, as by the organic remains found in them we are enabled to decipher much of the *unwritten* history of the earth during immensely distant periods.

Hugh Miller, sometimes called the "Prince of English Geologists," remarks, "All geologists agree in holding that the vast geological scale naturally divides into three great parts, — the palæozoic, or oldest fossiliferous division; the secondary, or middle; the tertiary, or latest." "In the first, or palæozoic division, we find corals, crustaceans, molluscs, fishes, and in its later formations a few reptiles." But that which specially distinguished this from the middle or tertiary "was its gorgeous flora. It was emphatically the period of plants," — of herbs yielding seed after their kind. In no "other age did the world ever witness such a flora," — "a rank and luxuriant herbage cumbered every foot breadth."

This rank herbage and the forest trees of that period have, by the wisdom and goodness of the Creator, been preserved for us of the present age for fuel and light. It is no matter of wonder to the geologist that such immense beds of mineral coal are found to exist, and such immense supplies of mineral oil.

Palæontology is the science that treats of fossils or organic remains. Rev. Dr. Hitchcock (late Geological Surveyor of Massachusetts, Vermont, etc.) says, "The number of species of animals and plants dug out of the rocks and described up to the present time (1860), cannot be less than thirty-five thousand, two thousand seven hundred and fifty of which are plants. The science of Palæontology opens a marvellous history of the ancient races, and peculiar forms of animals and plants that once lived on the globe. The thickness of the strata of rocks in which organic remains have been found is no less than fifty thousand feet." Most of the forms of animal life that existed in vastly remote periods would have been unknown to men of the present age, if their remains had not been intombed in the rocks formed while they existed. Some of these animals were of immense size and uncouth shape. They were adapted to the state of the earth as it then existed, as truly as the animals that now exist are to the condition of the globe at the present time. The degrees of cold and heat in different places have been so greatly modified, even since the continents assumed their present positions, that animals which once lived in Siberia, England, or this country, could not survive in either at the present time. Elephants once lived in Siberia, Russia, and Great Britain, but could not survive a single year in those countries now, unless protected by the care of man. Hugh Miller[1] states that "from only a limited tract of sea-bottom on the Norfolk coast, the fishermen engaged in dredging oysters, brought ashore, between 1820 and 1833, no fewer than two thousand elephants' grinders, besides great tusks, and numerous other portions of skeletons, requiring, it is thought, not less than five hundred of these huge animals to have supplied them. The remains of elephants are still so abundant amid the frozen wastes of Siberia, that what are not inappropriately called *ivory* quarries have been wrought among their bones for more than a hundred years." "Grand, indeed," says an English naturalist, "was the fauna of the British Islands in those early days. Tigers, as large again as the biggest Asiatic species, lurked in the ancient thickets; elephants, of nearly twice the bulk of the largest individuals that now exist in Africa and Ceylon, roamed in herds; at least two species of rhinoceros forced their way through the primeval forest; and the lakes and rivers were tenanted by hippopotami as bulky, and with as great tusks, as those of Africa." "The massive cave-bear and large cave-hyena belonged to the same formidable group, with at least two species of great oxen (*Bos longifrons* and *Bos primigenius*), with a horse of smaller size, and an elk (*Megaceros hibernicus*) that stood ten feet four inches in height. Truly this tertiary age — this third and last of the great geologic periods — was peculiarly the age of great beasts of the earth after their kind, and of cattle after their kind."[1]

---

[1] Miller's Testimony of the Rocks.

Both vegetables and animals are found in fossiliferous rocks. A few illustrations of some of these will interest the young.

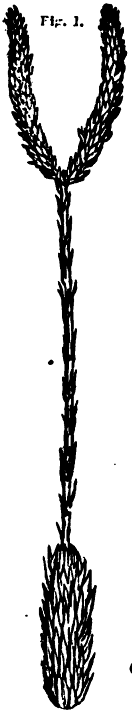
---

[1] Miller's Testimony of the Rocks.

Though there is a similarity in some of the mosses, ferns, etc., of existing flora to those found in the lower fossiliferous rocks, yet most of the latter differed materially from any now living.

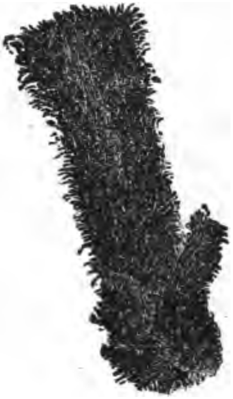
The Lycopodium Clavatum (club moss, Fig. 1) appears to be quite similar to specimens in the silurian rocks of Great Britain.

Fig. 1.



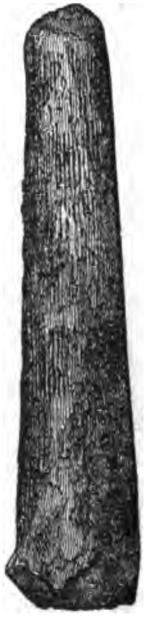
LYCOPODIUM CLAVATUM.

Fig. 2.



LYCOPODITE ?
Of the Lower Old Red Sandstone. Thurso.

Fig. 3.

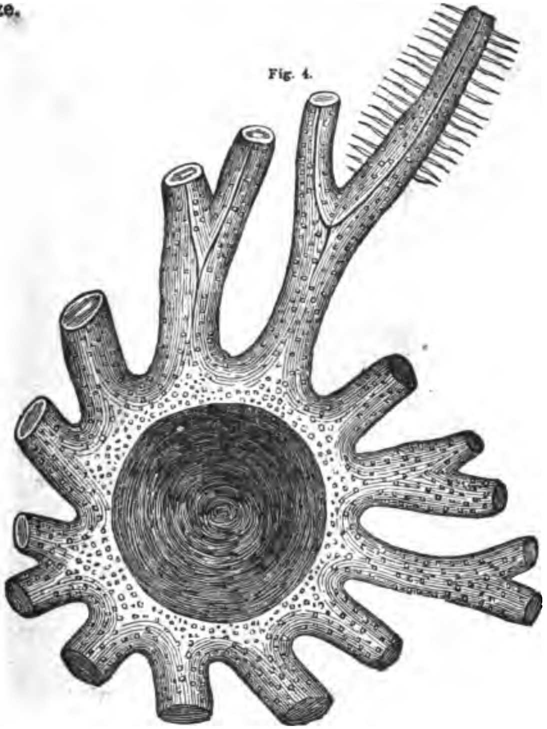


CALAMITE ?
Of the Lower Old Red Sandstone
Shetland.
(One eighth nat. size.)

The Lycopodite (Fig. 2), found in the old red sandstone, belonged to the ancient mosses. The figure is magnified two diameters.

The Calamite (ancient reed found in the old red sandstone, Fig. 3) is shown only one eighth of the natural size.

Fig. 4.



Stigmaria Ficoides (Fig. 4), a fossil plant of the ancient

Fig. 5.

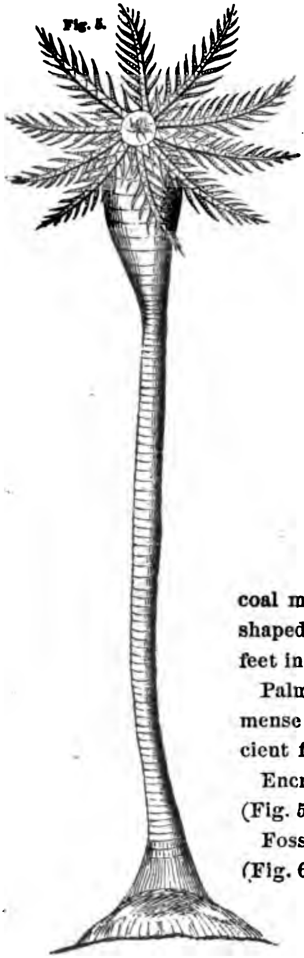
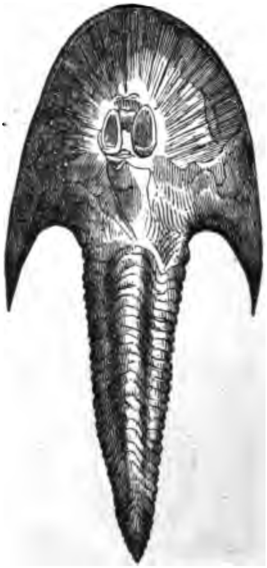


Fig. 6.



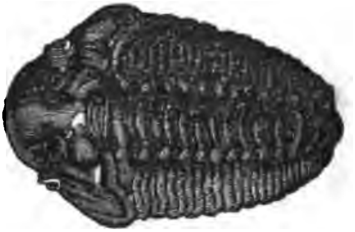
coal measures, had a large, dome-shaped mass, often three or four feet in diameter.

Palm-trees, and others of immense size, abounded in the ancient forests.

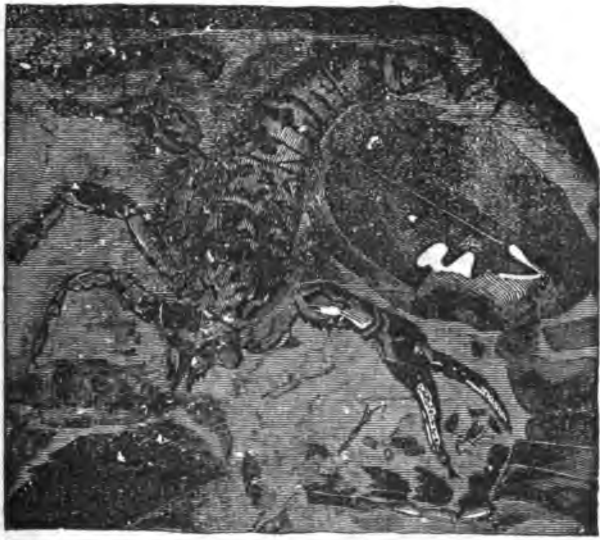
Encrinite of the Oölitic system. (Fig. 5.)

Fossils of the Silurian system. (Fig. 6.)

Fig. 7.



Trilobite. (Fig. 7.) Old Red Sandstone.



Fossil Scorpion. (Fig. 8.) Coal Measures of Bohemia.

Fig. 9.

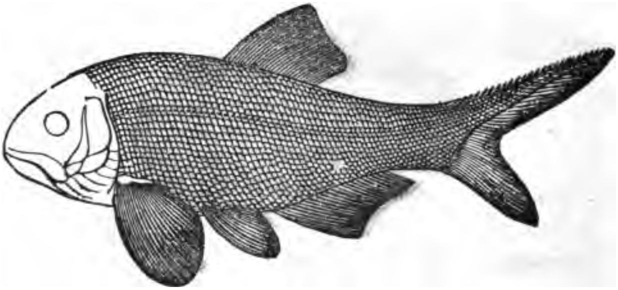
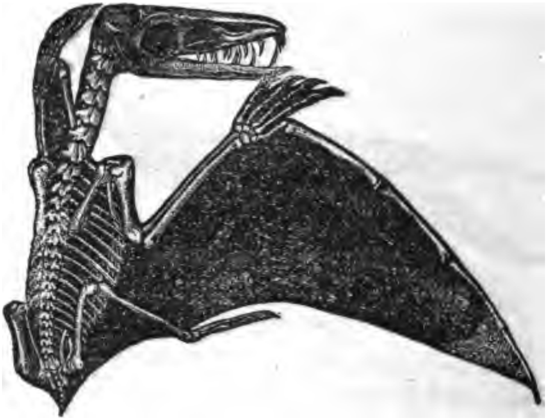


Fig. 10.

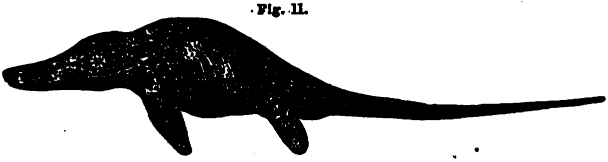


Fossil Fish. (Fig. 9.)

Flying Lizard. (Fig. 10.)

The spread of their wings was sometimes eighteen to twenty feet; their jaws and teeth like those of a crocodile, and wings like a bat.

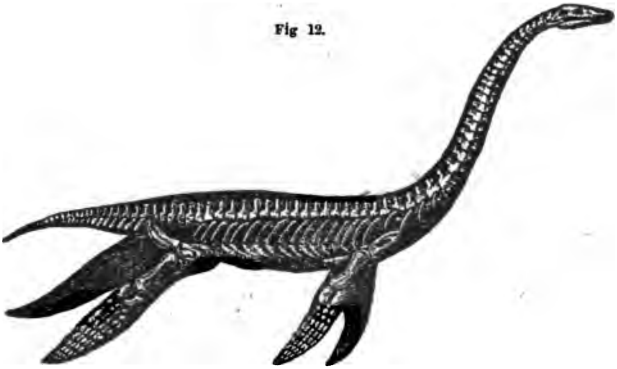
Fig. 11.



ICHTHYOSAURUS COMMUNIS.
(Lias.)

The Ichthyosaurus, or fish lizard (Fig. 11), combined in its structure the characteristics of a fish with those of a crocodile, of immense size.

Fig 12.

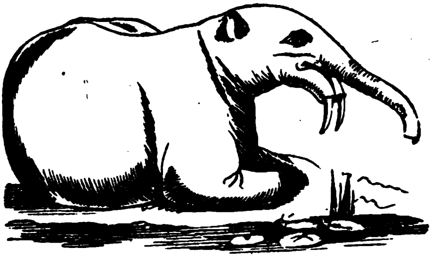


PLESIOSAURUS. *(Lias.)*

The Plesiosaurus (Fig. 12) existed at the same time, and was allied to the lizard and crocodile. It had an immensely long neck and short tail.

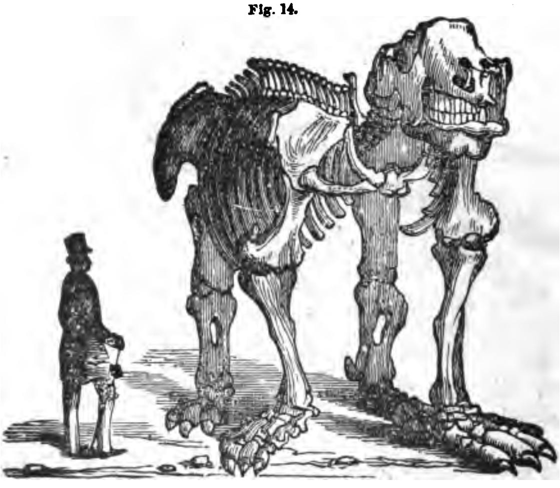
The Dinotherium (Fig. 13) was one of the greatest quadrupedal (four-footed) mammals that ever lived. He had great bent tusks at the end of the lower jaw, and was furnished with a trunk like the elephant. His name signifies "terrible beast." He was fifteen to eighteen feet in length, and very heavy.

Fig. 13.



DINOTHERIUM GIGANTEUM.
(Miocene.)

Fig. 14.



MEGATHERIUM.

The Megatherium (Fig. 14) was a gigantic quadruped.

Its name signifies "great wild beast." The thigh-bones were eleven inches in diameter, and his claw-armed toes were more than two feet in length. Fig. 14 represents the mere skeleton of this huge wild animal. Fig. 15 will give a better idea of the appearance when more fully restored.

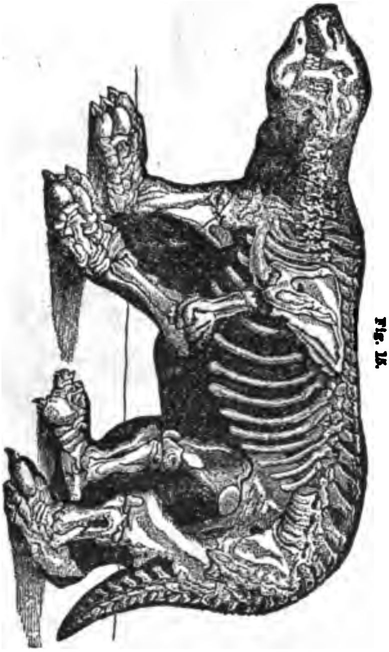


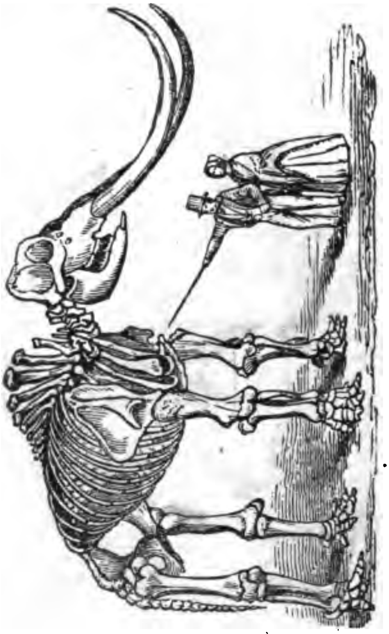
Fig. 15.

MEGATHERIUM CUVIERI.

The Megatherium lived at the same period with the Mastodon (Fig. 16.)

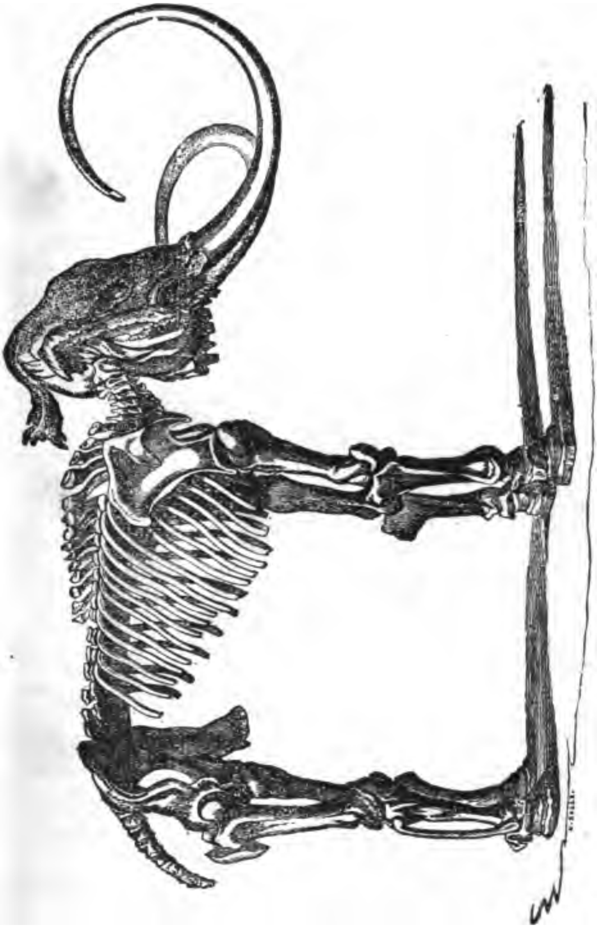
The Mastodon and Mammoth did not differ essentially from each other in form. The remains of the latter (Fig. 17) are found more abundant in Europe and Asia than in this country. No animals of equal bulk now exist. The elephant is the nearest in size, but the largest living species is dwarfish compared with those that lived in ancient times. All the ancient fauna have passed away, and have been succeeded by others better adapted to the present condition of the earth.

Fig 18.



"The works of God are great, sought out of all them that have pleasure therein." — *Psalm* cxi. 2.

Fig. 17.



ELEPHAS PRIMIGENIUS. *(Mammoth.)*

APPENDIX.

FAMILY AND SCHOOL CABINET.

Nine simple minerals have, with great propriety, been denominated the Alphabet of Geology.

These, separate, or combined in the formation of rocks, constitute a very large proportion of the crust or solid part of the earth. The names of these are, 1, quartz; 2, feldspar; 3, mica; 4, carbonate of lime (limestone); 5, sulphate of lime (gypsum); 6, clay, or argillite; 7, hornblende; 8, chlorite; 9, talc.

If to these are added ten of the metals, and four combustible minerals, the list will embrace at least ninety-nine-hundredths of the solid part of the earth's crust. Some knowledge of these ought to be obtained, as a part of the education of every person. The name of one or more of these occurs in almost every book or paper perused by the child in his general reading, and often in the text-books placed in his hands. The acquisition of such knowledge may, generally, be made as a relaxation from other pursuits, and be a source of amusement as well as benefit.

The following catalogue, embracing one hundred specimens, contains the most important and essential varieties, except the precious metals — gold, silver, and platina — and the diamond.

With the two former of these every child becomes early familiar, and the others are too expensive to be embraced in *cheap* cabinets.

I. Quartz.

The first letter of the alphabet, quartz, is nearly pure silex, or silica. It is the most useful of minerals, except iron, being essential in the formation of all varieties of glass for philosophical instruments, such as lenses, telescopes, and microscopes; also, spectacles, window-glass, glass ware, crockery and earthen ware, brick, cement, or mortar, etc. Silica enters into the composition of *most* rocks, and is the principal ingredient of many. Most of the "precious stones" mentioned in the Bible are principally silex. It is essential to a good soil, and constitutes a portion of many important plants. Silex forms nearly half of the crust of the earth.

1. Common quartz.
2. Milky quartz.
3. Smoky quartz.
4. Rose quartz.
5. Limpid quartz.
6. Ferruginous quartz.
7. Crystallized quartz.
8. Black quartz, inclining to flint.
9. Hornstone.

II. Feldspar.

This mineral, the second letter of the alphabet, is very useful, being the prominent ingredient in China ware and mineral teeth. It is capable of being formed into door-knobs, buttons, etc.

It aids in the formation of several valuable rocks, and furnishes important elements to soil.

10. Common feldspar.
11. Albite.
12. Tabular feldspar.
13. Labradorite.
14. Kaolin.

III. MICA.

Mica, the third letter, is foliated, and is known to most children by a false name, isinglass. It can usually be separated into very thin transparent laminæ, or leaves. It is useful for the transmission of light where glass would be broken or melted.

15. Common mica.
16. Smoky mica.
17. Iridescent mica.
18. Lepidolite.

IV. CARBONATE OF LIME (LIMESTONE).

The fourth letter of the alphabet is a very important mineral. When calcined, it forms quick-lime, so important in building, and very useful in agriculture. It constitutes all varieties of *true marble*, for grave-stones, ornamental building-stones, and statuary. It is much employed for lithographic printing, etc.

Carbonate of lime is an essential ingredient in good soils, as it enters into the composition of many useful vegetables. Probably an eighth part of the crust of the earth is carbonate of lime.

19. Blue (silicious) limestone.
20. Striped limestone.
21. Variegated limestone.
22. Stockbridge limestone.
23. Sparry limestone.
24. Encrinite limestone.
25. Water limestone.
26. Dolomite limestone (magnesian).
27. Statuary marble.
28. Statuary marble (Italian)
29. Black marble.
30. Dove marble.
31. Calcareous spar.
32. Rhomb spar.
33. Satin spar.
34. Calcareous tufa.
35. Shell marl.
36. Agaric mineral.
37. Organic remains in carbonate of lime.

V. Sulphate of Lime (Plaster of Paris).

The fifth letter of the geological alphabet is of great importance. It is the substance employed to form the moulds for casting stereotype plates, making casts of statues, ancient coins, etc.; also, the casts sold as toys.

A common name is gypsum. It is highly valuable when applied to soils deficient in lime, or sulphuric acid.

38. Common gypsum.
39. Brown gypsum.
40. Selenite (crystallized gypsum).

VI. Clay, or Argillite.

This is the sixth letter of the geological alphabet. Its most important uses are in the formation of brick, brown earthen ware, and in aiding to form the best varieties of soil.

41. Potter's clay.
42. Claystones.

VII. Hornblende.

Hornblende, the seventh letter, is important only as it aids in the formation of rocks and soils, and furnishes beautiful specimens for the cabinet.

It includes several minerals known under other names.

43. Massive hornblende.
44. Crystals of hornblende.
45. Radiated hornblende, in limestone (forming, when decomposed, one of the best varieties of soil.)
47. Common asbestos, or cotton stone.
48. Mountain cork.
49. Actinolite.
50. Tremolite.
51. Pargasite.
46. Asbestos (ligniform).

VIII. Chlorite.

This mineral, necessarily embraced in the geological alphabet, is of little importance in the arts, but aids in the formation of an extensive variety of rocks. It is usually dark-green, and very soft.

52. Chlorite.

IX. TALC.

This, constituting the ninth letter of the geological alphabet, is important, as aiding in the formation of those classes of rocks in which gold and silver are found. Talc is the softest of all minerals, and can, when pure, be cut with a knife without injury.

53. Common Talc.
54. Green talc, foliated.

X. ROCKS.

Two or more of the preceding simple minerals, when united, constitute many important rocks.

55. Granite, — quartz, feldspar, and mica.
56. Granite, fine grained (best building stone).
57. Granite, nodular.
58. Gneiss, — quartz, feldspar, and mica (stratified).
59. Syenite, — quartz, feldspar, and hornblende.
60. Mica slate, — mica and quartz.
61. Clay slate, — clay and quartz.
62. Chlorite rock, — chlorite and quartz.
63. Talcose slate, — talc and quartz.
64. Steatite, — talc and quartz.
65. Serpentine, — talc, quartz, and chrome.
66. Novaculite, — quartz and argillite.
67. Porphyry, — principally feldspar.
68. Sandstone, — quartz, lime, and iron.
69. Sandstone, clouded.
70. Burlington sandstone, with impressions of fucoides, rain-drops, etc.
71. Trap dike.

XI. CRYSTALLINE MINERALS.

Several of the preceding minerals, belonging to the geological alphabet, occur in the form of crystals. But even a small cabinet should contain others. The following numbers are therefore added. Some are quite rare, and all are interesting to the student in Mineralogy and Geology.

72. Schorl.
73. Tourmaline.
74. Staurotide.
75. Epidote.
76. Fibrolite.
77. Garnets, in mica slate.
78. Garnets, in hornblende rock.
79. Idocrase.
80. Macle.

XII. Metals and Ores.

Though the number of metals is large, the following varieties only, in addition to gold, silver, and tin, with which all are familiar, need be embraced in a small cabinet.

81. Iron (magnetic).
82. Franklinite.
83. Hematite, red.
84. Hematite, brown.
85. Iron pyrites.
86. Iron, chromate.
87. Iron, spathic (carbonate).
88. Iron, carburet (plumbago).
89. Manganese.
90. Copper ore.
91. Lead ore (galena).
92. Zinc ore (blende).
93. Molybdena.
94. Antimony.

XIII. Combustible Minerals.

95. Anthracite.
96. Lignite.
97. Asphaltum.
98. Cannel coal.
99. Bituminous coal.
100. Sulphur.

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THE END.

Alphabet of Geology.

Quartz.
Mica.
Feldspar.
Carbonate of Lime.
Sulphate of Lime.
Clay.
Hornblende.
Chlorite.
Talc.

When fences do devide us
And you and I to see
Ile help pull off a board

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